MAUL FOSTER ALONGI

MEMORANDUM

To: Dana Bayuk, DEQ | Date: May 29, 2015

From: Michael Murray, RG | Project No. 8128.01.12

James Peale, RG

RE: Supplement to Fill Water-Bearing Zone Groundwater Evaluation – Northern Portion of the Siltronic Corporation Property, Portland, Oregon ESCI No. 183

In an April 28, 2015, letter to Siltronic Corporation (Siltronic), the Oregon Department of Environmental Quality (DEQ) provided comments on the Fill Water-Bearing Zone Data Evaluation technical memorandum dated March 25, 2015 (Fill WBZ Evaluation) prepared by Maul Foster and Alongi, Inc. (MFA) for the Siltronic site. The letter indicated that DEQ "considers the Fill WBZ Evaluation to be incomplete as it focuses on evaluating the data only from the Phase 1 Step 6 test of the [Hydraulic Capture and Containment] HC/C system [and] Requests that Siltronic prepare a supplement to the document as indicated in our General Comment below."

This supplemental evaluation was prepared in response to DEQ's general and specific comments that were provided in a April 28, 2015 letter. MFA also attended two meetings with Anchor QEA LLC (AQ) and DEQ regarding the Phase 1 report prepared by AQ; the meetings occurred on May 12, 2015 and May 21, 2015. Additional guidance from the DEQ was obtained via a follow-up phone conversation on 5/15/2015, during which DEQ requested (and MFA agreed to) an analysis of groundwater response to Phase 1 pump testing during three distinct hydrologic conditions as approximated during three distinct Phase 1 pump tests, which are described below. Figure 1 presents the locations of monitoring wells included in this evaluation.

In summary, we find that:

- During some portion of each of the three pump tests evaluated, groundwater discharge to the Willamette River was reversed or reduced, based on groundwater elevations that were less than (or close to) the surface water elevations. Potential mechanisms explaining this effect include dewatering of the fill WBZ from HC/C operation, dynamic (rising/falling) river stage during the short pump test periods, and dynamic groundwater elevations that lag behind Willamette River stage.

- Fill WBZ well trends demonstrated two distinct sets of hydrologic behaviors: OW-1F, OW-2F, WS-8-33, and WS-44-29 were similar to each other and to the Willamette River. The hydrographs from WS-45-23, and WS-46-33, which are similar to each other, were distinctly different from the other hydrographs for the former wells.

- Groundwater specific conductance does not appear to be influenced by precipitation.

- Groundwater elevations increase with increasing river stage, especially at WS-44-29 and WS-45-23, suggesting that surface water is a significant source of recharge to the fill WBZ near these wells.

- Groundwater (and river stage) elevations do not necessarily increase during periods of increased precipitation, suggesting that precipitation is not a significant source of recharge to the fill WBZ.

Taken together, these observations indicate that (a) the Fill WBZ is hydraulically connected to the alluvium and the river near the NW Natural – Siltronic property line and adjacent to the river, but less connected to the alluvium with increasing distance from the river, and (b) primarily recharged by rising river stage and bank recharge, but not significantly recharged by precipitation. Consistent with the analysis in the "Fill Water Bearing Zone Trench Design Evaluation Report"[1], the saturated thickness of the Fill WBZ is very thin adjacent to the river.

These findings support reconsideration of the assumptions and input parameters for the MODFLOW model currently being developed to support demonstration of the HC&C system effectiveness. These findings also support reconsideration of the design and selection of SCM alternatives for the Fill WBZ.

The following sections describe the results of the supplemental evaluation prepared in response to DEQ comments. The latter portion of the document includes MFA's responses to DEQ's comments.

[1] Anchor QEA. 2015. Fill WBZ Trench Design Evaluation Report. Anchor QEA, LLC, Portland, Oregon. March 23.

RIVER STAGE AND PRECIPITATION DURING PHASE 1 TESTS

Phase 1 testing of the HCC system occurred intermittently between November 6, 2013 and October 20, 2014. A range of hydrologic conditions occurred during this period which could affect groundwater elevations. Figure 2 shows the Willamette River stage over the study period, with the Phase 1 test periods included for reference. Willamette River stage data was obtained from the United States Geological Survey (USGS) as recorded at station 14211720 ("Willamette River at Portland, Oregon").

To clarify the average river stage, a three-day Serfes rolling average was calculated to effectively remove the short period tidal signal and is overlaid as a green line in Figure 2. Generally, river stage was higher during the Phase 1, Steps 4 and 5 tests relative to the other step test periods. Lower river stages were observed during the Phase 1, Steps 1, 2, 3, and 6 tests compared to the other test periods. During each Phase 1 step test, the average river stage was dynamic (rising or falling), except for the Step 6 test. Table 1 presents average river stage data and other relevant hydrologic data for each of the Phase 1 test periods. Only wells containing transducers which record specific conductance (i.e. WS-42-36, WS-44-29, WS-45-23, and WS-46-33) are included in Table 1. Wells that do not measure specific conductance (i.e. OW-1F, OW-2F, and WS-8-33) are not included in Table 1.

Hourly precipitation data for the Phase 1 test period was obtained from the City of Portland Hydra rainfall network for station #121 "Yeon Rain Gage" and was plotted below Willamette River stage in Figure 3. Generally, more precipitation occurs during the spring and winter months, and precedes increases in Willamette River stage. However, precipitation alone does not appear to explain the changes in river stage. Average river stage and total precipitation during each of the Phase 1 pump test periods were summarized in Table 1.

FILL WBZ RESPONSE TO HCC OPERATION DURING PHASE 1 TESTS

In the "Fill Water Bearing Zone Groundwater Evaluation" dated March 25, 2015, MFA presented an evaluation of fill WBZ groundwater elevations during the Phase 1, Step 6 test. At DEQ's request, this supplemental analysis has been prepared to evaluate fill WBZ elevations relative to the Willamette River during three distinct hydrologic conditions:

Condition 1: low river stage and low groundwater elevations
Condition 2: low river stage and high groundwater elevations
Condition 3: high river stage and high groundwater elevations

Table 1 presents a summary of the six Phase 1 tests and illustrates the general hydrologic conditions that occurred during each test. The previously submitted "Fill Water Bearing Zone Groundwater Evaluation" included an evaluation of Condition 1 (the low river stage and low groundwater elevation condition - i.e. Phase 1, Step 6).

Since groundwater elevations closely follow Willamette River stage, no one step test accurately represents Condition 2 (i.e. low river stage and high groundwater elevation). Acknowledging that Condition 2 may not actually exist, MFA selected the Phase 1, Step 1 and 2 tests as the best approximation of Condition 2. MFA believes that the Phase 1, Steps 1 and 2 tests more accurately represent Condition 2 compared to the Phase 1, Step 3 test period because the Willamette River stage was more stable during the Phase 1, Steps 1 and 2 tests. Comparison of groundwater elevations to Willamette River stage during time periods of dynamic rive stage (such as occurred during the Phase 1, Step 3 test) could confound the analysis by introducing uncertainty regarding the underlying cause of the water elevation differences presented in the hydrographs. For example, when river stage is rising during a step test, negative water elevation differences could be due to a transient increase in river stage that is higher in elevation than the groundwater elevation. In this case, it could be difficult to confirm that alluvial pumping by the HC/C system dewatered the fill WBZ.

Condition 3 (high river stage and high groundwater) was represented by the Phase 1, Step 4 test instead of the Phase 1, Step 5 test because the of very low amount of precipitation recorded during the Phase 1, Step 5 test when compared to the other test periods. Neither the Phase 1, Step 4 or the Phase 1, Step 5 pump tests occurred exactly at the highest river stage and highest groundwater elevation conditions observed over the course of the Phase 1 testing.

Plots of Condition 2 (i.e. Phase 1, Steps 1 and 2 test) are included as Figures 4 through 9, and Condition 3 (i.e. Phase 1, Step 4 test) are included as Figures 10 through 15. For consistency, the plots follow the same format used in MFA's original March 25, 2015 evaluation. Each figure represents one well and contains three subplots:

- The top plot shows fill WBZ groundwater elevations plotted with the Willamette River stage, and includes Serfes three-day rolling averages for both.
- The middle plot shows the difference between fill WBZ elevation and Willamette River stage.
- The bottom plot shows the Serfes three-day rolling average of the difference between fill WBZ elevation and Willamette River stage (i.e. the information presented in the middle subplot).

Table 1 summarizes groundwater elevation trends during each of the Phase 1 pump test periods. Groundwater elevations cluster into two groups during all tests: low groundwater elevations were observed at OW-1F, OW-2F, WS-8-33, and WS-44-29; and higher groundwater elevations were observed at WS-45-23 and WS-46-33.

Condition 1: Low river stage and low groundwater elevation (Phase 1, Step 6)

An analysis of the Phase 1, Step 6 test period was presented in MFA's "Fill Water Bearing Zone Groundwater Evaluation" dated March 25, 2015. The Willamette River stage was generally stable during the test period (not rising or falling). Table 1 summarizes hydrologic conditions and data from the wells during the test period.

Generally, groundwater elevations declined during this test period. Some water elevation differences were negative, likely in response to alluvial pumping loss of fill WBZ groundwater in response to the Phase 1, Step 6 pump test. Groundwater elevations cluster into two groups during this test: lower groundwater elevations observed at OW-1F, OW-2F, WS-8-33, and WS-44-29; and higher groundwater elevations observed at WS-45-23 and WS-46-33. A tidal signal was observed at WS-44-29 and WS-46-33, but not at the other wells.

Condition 2: Low river stage and high groundwater elevation (Phase 1, Steps 1 and 2)

Figures 4 through 9 show the Phase 1, Steps 1 and 2 test period for six fill WBZ wells: OW-1F, OW-2F, WS-8-33, WS-44-29, WS-45-23, and WS-46-33. Figure 2 shows the Willamette River stage during the test period (falling). Table 1 summarizes hydrologic conditions and data from the wells during the test period.

Generally, groundwater elevations were stable during this test period. While there were some water elevation differences (bottom plot) that were negative, it is likely that this was an effect of the initially high river stage observed throughout the duration of the Phase 1, Steps 1 and 2 test. Negative groundwater elevation differences indicate that surface water could be recharging the fill WBZ. Groundwater elevations cluster into two groups during this test: lower groundwater elevations observed at OW-1F, OW-2F, WS-8-33, and WS-44-29; and higher groundwater elevations observed at WS-45-23 and WS-46-33. A tidal signal was observed at WS-44-29 and WS-46-33, but not at the other wells.

Condition 3: High river stage and High groundwater elevation (Phase 1, Step 4)

Figures 10 through Figure 15 show the Phase 1, Step 4 test period for six fill WBZ wells: OW-1F, OW-2F, WS-8-33, WS-44-29, WS-45-23, and WS-46-33. Figure 2 shows the overall nature of the Willamette River stage during the test period (rising). Table 1 summarizes hydrologic conditions and data from the wells during the test period.

Generally, groundwater elevations appear to fall during the test period even though the Willamette River stage is rising. This leads to negative water elevation differences (bottom plot) during the Phase 1, Step 4 test. The decline in fill WBZ groundwater elevations may be related to alluvial pumping, or the negative water elevation differences could be a due to the rising river stage during this pump test, or a combination of both. The apparent falling groundwater elevations during this test could also be a result of the lag time between river stage and groundwater elevations.

The groundwater elevations cluster into two groups during this test: lower groundwater elevations observed at OW-1F, OW-2F, WS-8-33, and WS-44-29; and higher groundwater elevations observed at WS-45-23 and WS-46-33. A tidal signal was observed at WS-44-29 and WS-46-33, but not at the other wells.

SPECIFIC CONDUCTANCE TRENDS DURING PHASE 1 TESTS

A subset of the fill WBZ water level transducers installed by MFA also measure specific conductance at 15-minute intervals. Plots of the four fill WBZ wells that record specific conductance (i.e., WS-44-29, WS-45-23, WS-46-33, and WS-42-36 [an upland well included for reference]) are included as Figures 16-19. Note that in wells WS-44-29 and WS-45-23, the specific conductance signal drops or becomes noisy when the groundwater elevation was low (due to low amounts of groundwater present on the sensor). In general, upland (WS-42-36) groundwater had a higher specific conductance than groundwater at wells located near the Willamette River. For some wells (WS-44-29 and WS-45-23), specific conductance follows groundwater elevations (i.e. specific conductance was high when groundwater elevations were high).

Figure 20 presents the specific conductance values for four fill WBZ wells and the Willamette River (obtained from the USGS) plotted together over the Phase 1 test period. Generally, the specific conductance trends at WS-42-36 and WS-46-33 were similar to each other, but different from the specific conductance trends at WS-44-29 and WS-45-23 (which were similar to each other). The Willamette River specific conductance was much lower and does not fluctuate as much as the groundwater data.

To examine the influence of precipitation on groundwater specific conductance, concurrent measurements of these two parameters at each of the four wells were plotted in Figure 21. The scatterplot demonstrates that groundwater specific conductance did not decrease during periods of increased precipitation. Therefore, the data do not indicate that the specific conductance signal in groundwater was diluted by rainwater infiltrating to the Fill WBZ. Thus, it can be inferred that infiltration of precipitation was not a significant source of recharge to the Fill WBZ. This conclusion is supported by the groundwater elevation response to precipitation events discussed below.

CORRELATION ANALYSIS

Correlation coefficients were calculated in order to evaluate potential relationships between measured parameters such as specific conductance, precipitation, river stage, and groundwater elevation. Recall that correlation coefficients near 1 or -1 infer dependence between the two variables, whereas values near zero suggest no connection between the two variables. Furthermore, a positive correlation coefficient means that as the value of one variable increases, the value of the other variable increases; as one decreases the other decreases. A negative correlation coefficient indicates that as one variable increases, the other decreases, and vice-versa.

The correlation analysis was performed on averaged data from the Phase 1 steps presented in Table 1 (note that precipitation data were summed, not averaged). The results of the correlation analysis are summarized in Table 2 where the variable in each row is compared to the variable in the corresponding column, with the following observations:

- Precipitation and specific conductance correlations generally suggest that the two variables are not related. The highest correlation coefficient (0.66 at upland well WS-42-36) is positive and indicates that specific conductance increases with increased precipitation, which is counter to the causal relationship posited by DEQ in its comments. Specific conductance in the Willamette River has a correlation coefficient of -0.62 with precipitation indicating a fair amount of correlation between increased precipitation and falling specific conductance values, as expected. Precipitation and specific conductance were positively correlated in WS-42-36 and less so in WS-46-33. The variables were weakly negatively correlated in WS-44-29 and WS-45-23.

- Precipitation and groundwater/surface water elevation comparisons return correlation coefficients that were all negative, indicating that increased groundwater (and river stage) elevations were not related to increased precipitation (i.e. groundwater and river stage elevations increase independently of precipitation). This also suggests that precipitation was not a significant source of recharge to the fill WBZ. At WS-42-36 and WS-46-33, correlation coefficients of -0.82 and -0.83 indicate strong inverse dependence between precipitation and groundwater elevations at these locations. That is, the presumed causal link between precipitation as recharge and groundwater elevation increases cannot be supported. The correlation coefficients for WS-44-29, WS-45-23, and the Willamette River are weaker but also negative, which again does not support the presumed causal link.

- Willamette River stage and groundwater elevations return strongly positive correlation coefficients, indicating a strong dependence between these variables. WS-42-36 and WS-46-33 both had similar correlation coefficients while WS-44-29 and WS-45-23 had similar (and stronger) correlation coefficients, indicating similar responses within these groups.

- Willamette River stage and specific conductance comparisons returned a range of correlation coefficients. Correlation coefficients are very low (no dependence) for Willamette River stage and specific conductance at WS-42-36, WS-46-33, and the Willamette River. Willamette River stage had a strong positive correlation to specific conductance at WS-44-29 and WS-45-23. It is possible that the correlation is caused by a mechanism where increased saturated thickness (potentially resulting from bank recharge) drives increasing specific conductance at these locations (recall from the above paragraph that WS-44-29 and WS-45-23 groundwater elevations closely follow Willamette River stage).

Note that in all of the correlation coefficient calculations, WS-42-36 and WS-46-33 returned similar values, and WS-44-29 and WS-45-23 returned similar values. However, these two pairs have distinctly different values when compared to each other.

RESPONSE TO DEQ COMMENTS

MFA's response to specific DEQ comments provided in the April 28, 2015 letter are summarized below:

DEQ General Comment:
"The Phase 1 tests have been run with the purpose of evaluating HC&C system performance during various groundwater and river stage conditions. The Fill WBZ Evaluation focuses on compiling water level data recorded during the Phase 1 Step 6 test. Furthermore, the document bases the overall evaluation of the Fill WBZ data collected during Phase 1 testing on the Step 6 test. Consequently, the report only evaluates the data collection objectives in the context of a single set of groundwater and river stage conditions (i.e., relatively low groundwater levels and low river stage).
Document Supplement
The Fill WBZ Evaluation presents for the first time data collected from numerous monitoring wells completed in the fill on the Siltronic site, but only for a single Phase 1 test. Based on this information, DEQ requests that Siltronic prepare a supplement to the Fill WBZ Evalution [sic] that provides additional figures for the Fill WBZ under conditions representative of the range of groundwater and river conditions observed during Phase 1 testing (e.g., relatively high groundwater levels and high river stage; relatively high groundwater levels and low river stage)."

MFA Response to Comment: While MFA recognizes that the Phase 1, Step 6 test reflects only one hydrologic condition, MFA evaluated this test for the following reasons:

- This test represented the most refined and most likely set of operational parameters that will be used in the long term operation of the HC/C system (representing actual HC/C system operational conditions).
- The Willamette River stage was dynamic (rising/falling) during all of the Phase 1 tests, but was the most stable during the Phase 1, Step 6 test. A stable river stage is critical when comparing groundwater elevations to a tidal river stage.
- Phase 1, Step 6 testing occurred during a time with low groundwater elevations and low river stage, representing the worst case scenario for HCC operation.

DEQ Specific Comment: "Siltronic concludes that, "The HCSM for the Fill water bearing zone is not understood well enough and does not provide a defensible basis of design for source control measure alternatives, including the proposed design previously approved by DEQ. As such, we do not recommend moving forward with alternatives selection, design, or construction at this time." DEQ disagrees with Siltronic's assertion in the first sentence and does not accept the recommendation provided in the second. As indicated above, water levels in the Fill WBZ will continue to be monitored during HC&C system testing to further evaluate the relationship between the Fill WBZ and upper Alluvium WBZ. That said, DEQ considers the hydrogeologic conceptual site model (HCSM) for the Fill WBZ to be generally established and supportive of the ongoing source control planning and design process."

MFA Response to Comment: MFA does not agree with DEQ regarding the current understanding of the Fill WBZ HCSM. The Fill WBZ has been demonstrated to be heterogeneous and hydraulically complex, as indicated by a DEQ comment below. MFA agrees that an evaluation of Fill WBZ response to the Phase 2 testing will do much to inform the Fill WBZ HCSM.

DEQ Specific Comment: "The data discussions and conclusions presented in the Fill WBZ Evaluation focus on a limited number of scenarios or interpretations. In many cases the data and/or data trends are discussed in terms of a single scenario/interpretation. Examples include the following:

- "Throughout the Fill WBZ Evaluation the focus of discussions is on the occurrence of "silt" at the base of the fill. In other words, Siltronic's discussions and conclusions on the potential connection between the Fill WBZ and Alluvium WBZ are limited to the occurrence of a specific material type. Table 2 of the document summarizes Siltronic's interpretations regarding the occurrence of "silt" at numerous drilling locations at the site. DEQ considers Siltronic's focus on "silt" to unnecessarily limit discussions of the site hydrogeology. Packages of fine-grained sediments consisting of mixtures of silts and sands (e.g., silt, silty sand, sandy silt) at the base of the fill and in the upper-Alluvium WBZ could limit the hydraulic connection between the Fill WBZ and the Alluvium WBZ and restrict downward vertical migration of groundwater. The Phase 1 HC&C tests support this comment."

MFA Response to Comment: MFA acknowledges that the upland native silt and in river native silt units are heterogeneous and variably contain mixtures of multiple different size fractions, ranging from clay to gravel.

The underlying silt layer has been identified in multiple reports and design documents as a functional component of the site hydrogeology, and provides the basis for the presumption that Fill WBZ groundwater can be captured by the recommended alternatives identified by AQ in the Fill WBZ Trench Design Evaluation Report. Furthermore, the upper surface of the silt was identified by DEQ as the criteria for locating the screens in the Fill WBZ wells per DEQ comments[2] . In other words, the "underlying silt unit" has been a consistent hydrogeologic feature throughout the investigation and design process at the Gasco and the Siltronic sites.

For the purpose of maintaining of consistency with previous documents MFA will therefore continue to identify the lower-permeability units separating the Fill WBZ and the alluvium as upland native silt and in-river native silt, where either is present, and consistent with the interpretation provided in the March 25, 2015 Fill WBZ memorandum. MFA notes that the upland silt unit has in

[2] DEQ. 2013. Electronic Mail (re: Siltronic, Revised Fill WBZ Monitoring Well Installation Work Plan) to K. Gallagher and J. Peale, Maul Foster & Alongi, Inc., Portland, Oregon, from D. Bayuk, Oregon Department of Environmental Quality, Portland, Oregon. August 6.

multiple prior documents been identified as discontinuous, allowing for connection between the Fill WBZ and the underlying alluvium, which is also supported by data from the Phase 1 HC&C tests.

DEQ Specific Comment:

- "Siltronic indicates that, "…during the higher set point/flow rate Phase 1 pumping tests, fill WBZ groundwater elevations decrease, regardless of Willamette River stage trends…" The document further indicates that, "…the decreasing fill WBZ groundwater elevations during Phase 1 tests indicate a response in the fill WBZ groundwater elevations related to HC/C system pumping." DEQ believes another valid interpretation of these data trends is that groundwater level trends lag behind changes in river stage near the end of the testing period. Monitoring of water levels during Phase 2 testing will be used to further assess the relationship in water level trends between the Fill WBZ and river stage."

MFA Response to Comment: MFA concurs with DEQ that groundwater elevations lag behind river stage. Phase 2 testing will be useful in evaluating Fill WBZ response over a range of river stages.

DEQ Specific Comment:

- "The Fill WBZ Evaluation indicates that based on specific conductance data shallow groundwater is recharged by the Willamette River. According to the document specific conductance data, "…suggests that all riverfront fill WBZ groundwater is being diluted by surface water from the Willamette River." Siltronic further indicates recharge is occurring in the uplands more than 200-feet from the top-of-bank (i.e., at monitoring well WS-45-23). The evaluation does not mention or assess other factors that could influence the specific conductance of shallow groundwater, including but not limited to: seasonal fluctuations, the number and timing of field measurements, and the composition of fill material. For example, based on data compiled through March 2015 by Siltronic, specific conductance has been measured at WS-44-29, WS-45-23, and WS-46-33 two times in December 2014 and March 2015. These measurements correspond to periods of seasonal precipitation. Consequently, the measurements are likely influenced by recharge of the Fill WBZ by seasonal precipitation. Precipitation represents a source of recharge to the Fill WBZ by water low in specific conductance that is entirely separate from the river. Based on this information DEQ considers Siltronic's interpretation of the specific conductance data to be incomplete."

MFA Response to Comment: An expanded evaluation of specific conductance data is included in this Fill WBZ supplement and includes evaluation of the other factors suggested by DEQ. Based on specific conductance data collected from transducers (i.e. WS-42-36, WS-44-29, WS-45-23, and WS-46-33), MFA has concluded that precipitation has no significant influence on specific conductance data.

DEQ Specific Comment: "Siltronic indicates that water levels in WS-42-29 [sic] declined 1.24-feet during the Phase 1 Step 6 test. The basis for this conclusion is not clear to DEQ as the decrease in water levels shown by Figure 13 do not appear to be reflected in Figure 9. DEQ requests that Siltronic provide additional information and data to support the interpretation in the supplement to the Fill WBZ Evaluation."

MFA Response to Comment: In the Fill WBZ Evaluation, MFA observed that water levels at WS-*44*-29 fell below the installed depth of the transducer (which is installed 1.24 feet above the top of the confining layer). This means that during the Phase 1, Step 6 test, water levels at WS-44-29 dropped below the recordable range of the instrument to an elevation near the confining layer (i.e. the Fill WBZ was dewatered).

WS-44-29 water levels shown in Figures 9 and 13 do not differ; the water level in the later part of the Step 6 test was approximately 4.9 feet (NGVD-29) in both plots. A red line is used to indicate groundwater elevations in WS-44-29 in both figures. In Figure 13, the blue line indicates specific conductance, which fell to zero (i.e. the transducer is not in water) at the same time that the water level fell to 4.9 feet (thus the transducer is not in water during the latter portion of the Step 6 test).

DEQ Specific Comment: "Future monitoring should include instrumentation of upgradient fill wells WS-41-36 and WS-42-36. Continuous monitoring of these wells will provide useful data in the fill zone upgradient of the more tidally influenced near shore Fill WBZ installations to help remove tidal influence in the evaluation of vertical recharge and HC&C system influence and to improve characterization of recharge and discharge patterns in the Fill WBZ for the HCSM."

MFA Response to Comment: A water level transducer was installed in well WS-42-36 on September 14, 2013 and remains active. An additional water level transducer will be installed in well WS-41-36 per DEQ direction.

Attachments: Figures
Tables

cc: Myron Burr, Siltronic Corporation
Ilene Gaekwad and William Earle; Davis Rothwell Earle & Xochihua
Chris Reive, Jordan Ramis
Keith Johnson, DEQ
Henning Larsen, DEQ
Matt McClincy, DEQ
Kristine Koch, EPA
Sean Sheldrake, EPA
Rene Fuentes, EPA
Lance Peterson, CDM
Bob Wyatt, NWN

Patty Dost, Pearl Legal Group LLC
Ben Hung, Anchor QEA LLC
John Edwards, Anchor QEA LLC
Carl Stivers, Anchor QEA LLC
Rob Ede, Hahn and Associates, Inc.

TABLES

Table 1
Average Hydrologic Values
Siltronic Corporation
Portland, Oregon

Phase 1 Test:	Total Precipitation* (inch)	Willamette River		WS-42-36		WS-44-29		WS-45-23		WS-46-33		Hydrologic Trend	Hydrologic Condition
		Stage (ft NGVD-29)	Sp.Cond (uS/cm)	WLE (ft NGVD29)	Sp.Cond. (uS/cm)	WLE (ft NGVD29)	Sp.Cond. (uS/cm)	WLE (ft NGVD29)	Sp.Cond. (uS/cm)	WLE (ft NGVD29)	Sp.Cond. (uS/cm)		
Steps 1 and 2	1.27	5.38	65	18.61	1330	6.20	546	12.62	361	12.50	876	Low River Stage High Groundwater Elevation	Condition 2
Step 3	0.87	5.33	63	18.64	1373	6.33	524	12.65	327	12.40	876	Low River Stage High Groundwater Elevation	Condition 2
Step 4	1.31	7.76	61	19.22	1383	8.87	614	13.36	377	13.12	856	High River Stage High Groundwater Elevation	Condition 3
Step 5	0.03	7.56	82	20.11	1193	8.13	578	13.14	348	14.39	684	High River Stage High Groundwater Elevation	Condition 3
Step 6	1.30	4.45	77	18.67	1266	5.11	212	12.34	263	12.18	640	Low River Stage Low Groundwater Elevation	Condition 1
Water Elevation Trend:		Riverine		Upland		Riverine		Near-Shore		Near-Shore		--	--

Notes:

*Total Precipitation is not an average value, it is a sum of precipitation during the individual step test.

ft: feet

NGVD29: National Geodetic Vertical Datum of 1929

Sp.Cond: Specific Conductance

uS/cm: microsiemens per centimeter

WLE: Water Level Elevation

Table 2
Correlation Coefficients
Siltronic Corporation
Portland, Oregon

	Total Precipitation	Willamette River Stage
WS-42-36 Specific Conductance	0.69	-0.09
WS-44-29 Specific Conductance	-0.33	0.76
WS-45-23 Specific Conductance	-0.13	0.74
WS-46-33 Specific Conductance	0.35	0.11
Willamette River Specific Conductance	-0.62	0.01
WS-42-36 Groundwater Elevation	-0.82	0.81
WS-44-29 Groundwater Elevation	-0.36	0.99
WS-45-23 Groundwater Elevation	-0.35	0.99
WS-46-33 Groundwater Elevation	-0.83	0.83
Willamette River Stage	-0.46	--

FIGURES

Figure 1
Fill Water Bearing Zone Well Locations

Siltronic Corporation
Portland, Oregon

Legend

- Siltronic Monitoring Well
- Northwest Natural Monitoring Well
- Siltronic Tax Lot

0 40 80
Feet

Source: Aerial photograph obtained from Esri ArcGIS Online

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p. 971 544 2139 | www.maulfoster.com

Path: X:\8128.01 Siltronic Corp\12\Projects\08\Fig1_Fill Water Bearing Zone Well Locations.mxd
Print Date: 5/28/2015
Approved By: jpeale/mmurray
Produced By: jschane
Project: 8128.01.12

Figure 2: Willamette River Stage

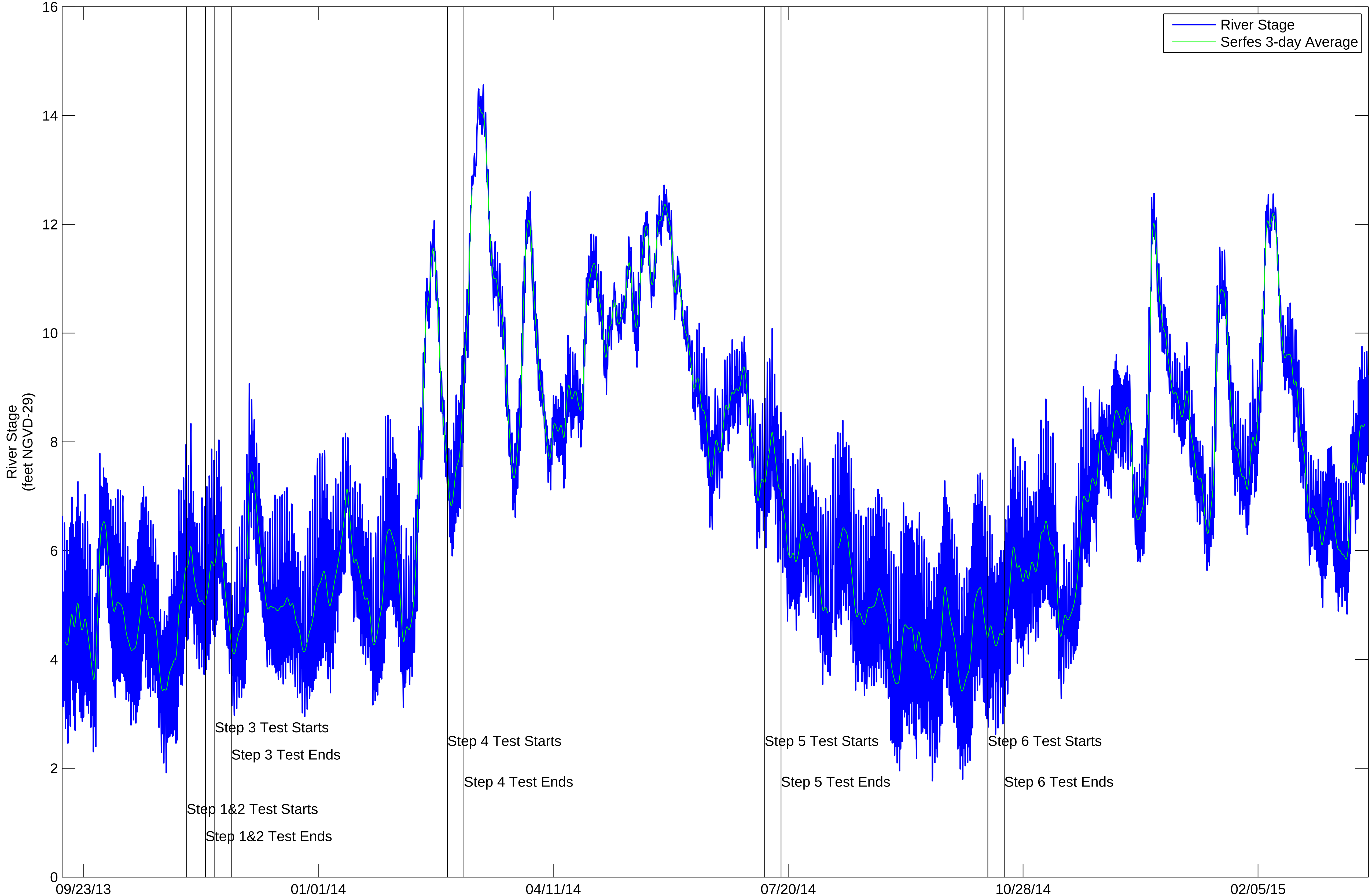
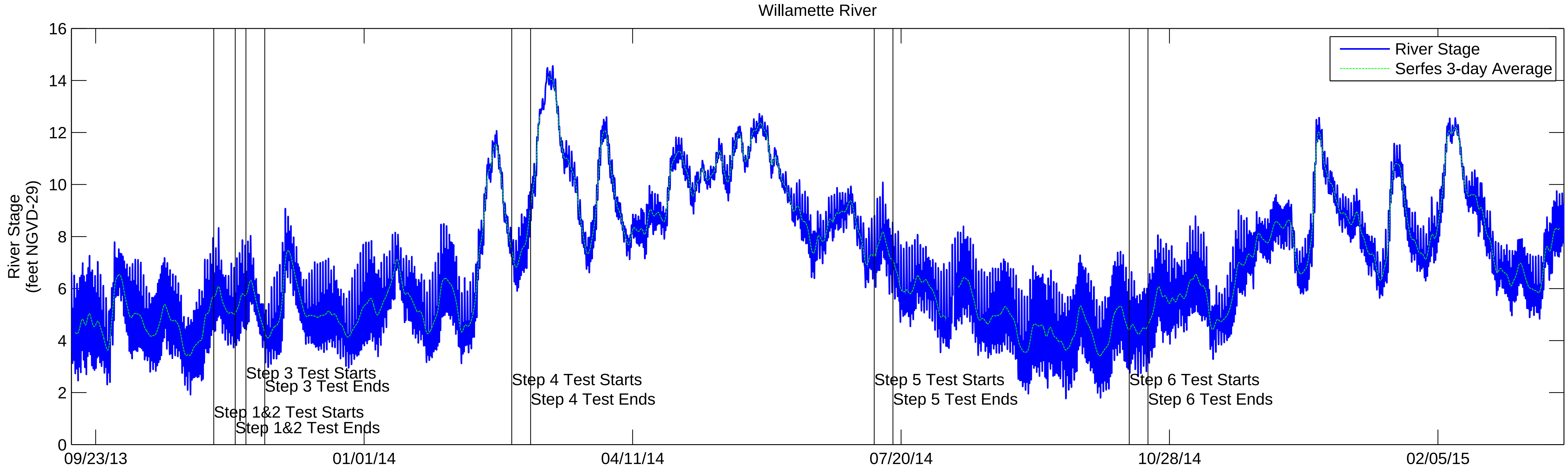


Figure 3


Willamette River
River Stage
Serfes 3-day Average
River Stage
(feet NGVD-29)
Step 1&2 Test Starts
Step 1&2 Test Ends
Step 3 Test Starts
Step 3 Test Ends
Step 4 Test Starts
Step 4 Test Ends
Step 5 Test Starts
Step 5 Test Ends
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10/28/14
02/05/15

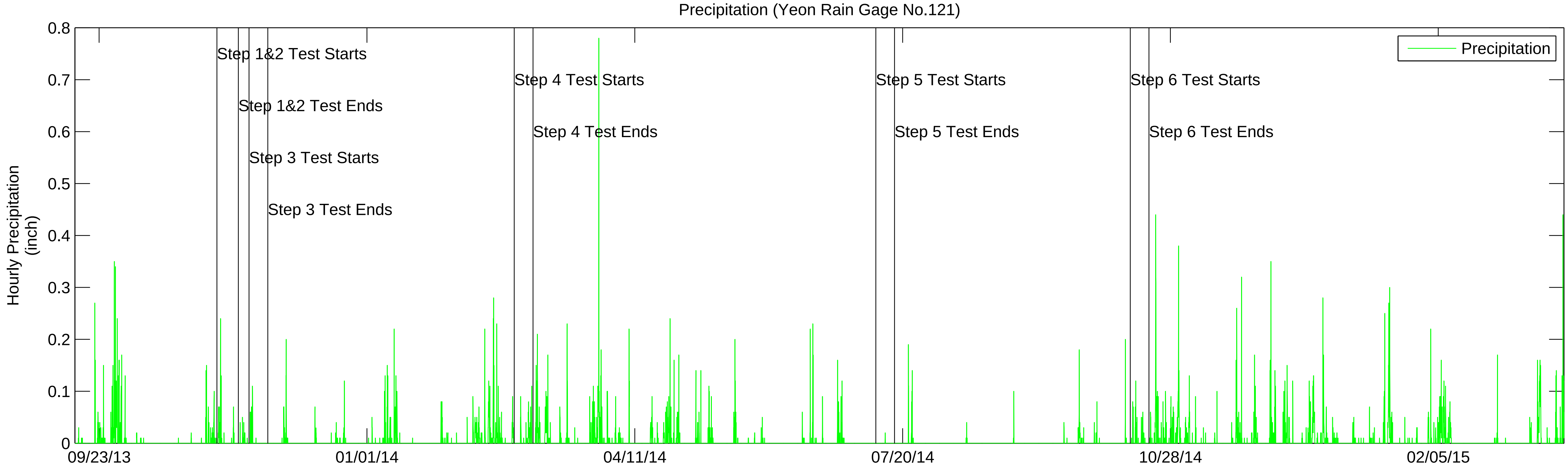
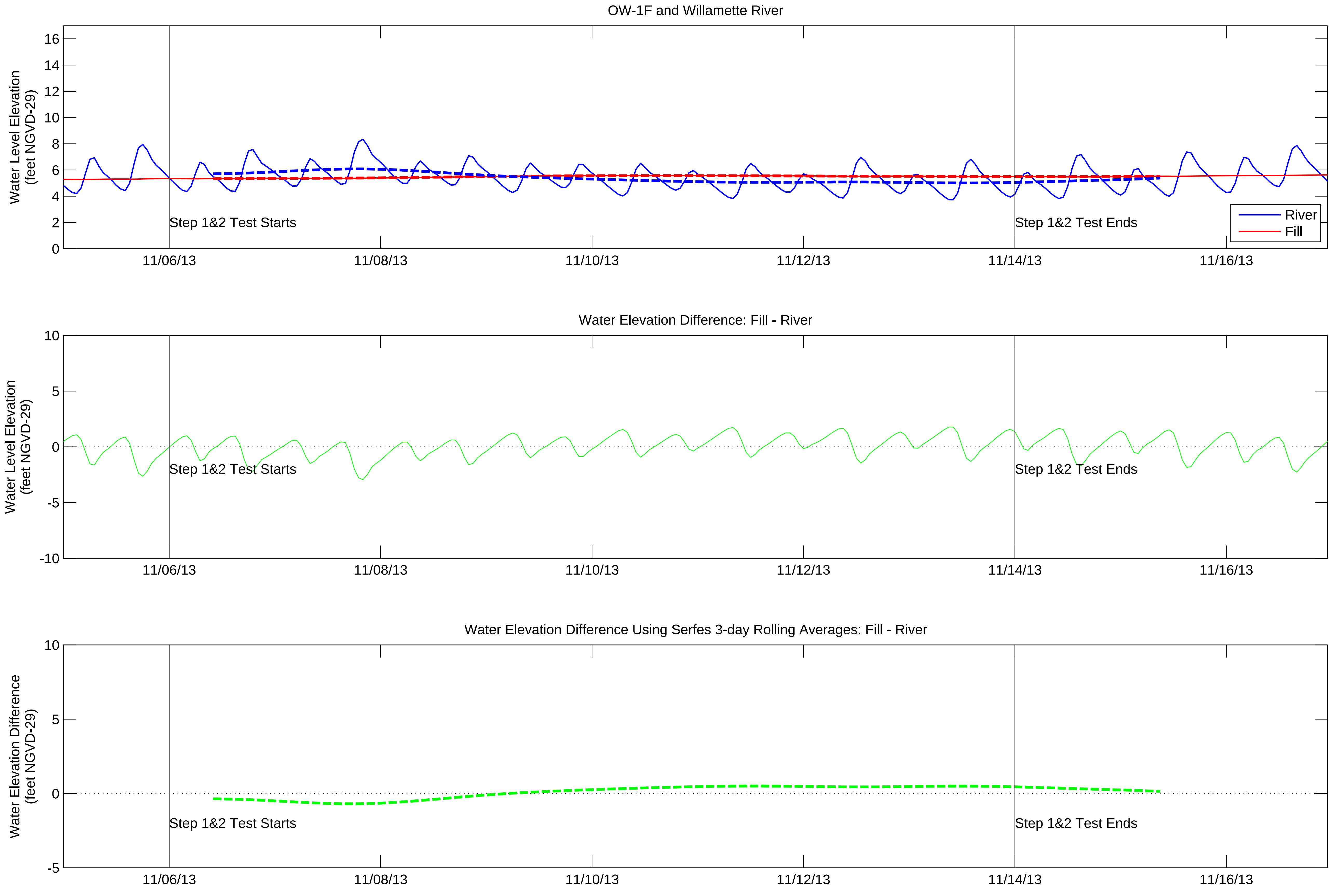

Precipitation (Yeon Rain Gage No.121)
Precipitation
Hourly Precipitation
(inch)
Step 1&2 Test Starts
Step 1&2 Test Ends
Step 3 Test Starts
Step 3 Test Ends
Step 4 Test Starts
Step 4 Test Ends
Step 5 Test Starts
Step 5 Test Ends
Step 6 Test Starts
Step 6 Test Ends
09/23/13
01/01/14
04/11/14
07/20/14
10/28/14
02/05/15

Figure 4



OW-1F and Willamette River
Water Level Elevation (feet NGVD-29)
16
14
12
10
8
6
4
2
0
Step 1&2 Test Starts
Step 1&2 Test Ends
River
Fill
11/06/13
11/08/13
11/10/13
11/12/13
11/14/13
11/16/13
Water Elevation Difference: Fill - River
Water Level Elevation (feet NGVD-29)
10
5
0
-5
-10
Step 1&2 Test Starts
Step 1&2 Test Ends
11/06/13
11/08/13
11/10/13
11/12/13
11/14/13
11/16/13
Water Elevation Difference Using Serfes 3-day Rolling Averages: Fill - River
Water Elevation Difference (feet NGVD-29)
10
5
0
-5
Step 1&2 Test Starts
Step 1&2 Test Ends
11/06/13
11/08/13
11/10/13
11/12/13
11/14/13
11/16/13

Figure 5

WS46-33 and Willamette River

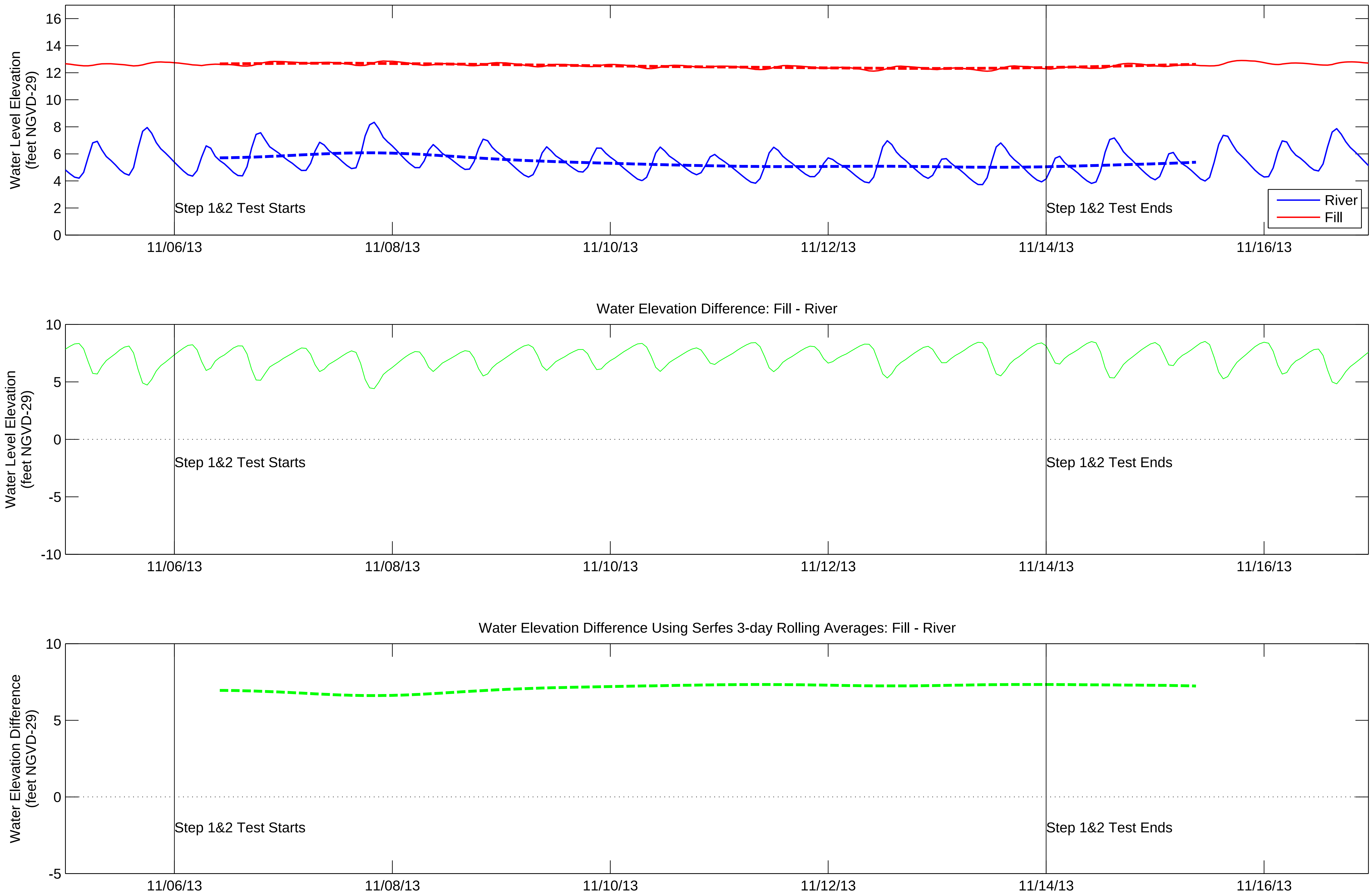


Figure 6

WS45-23 and Willamette River

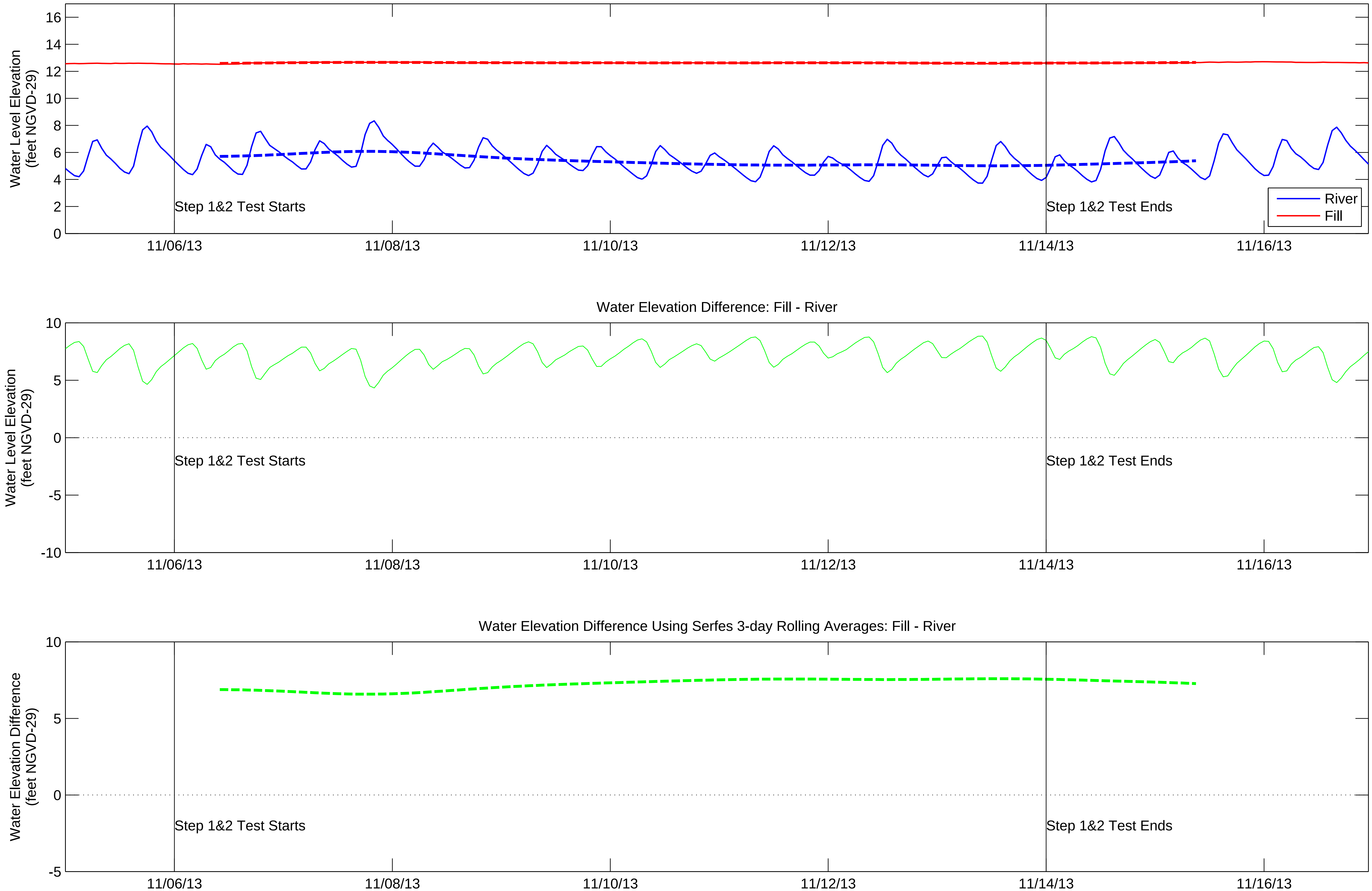


Figure 7

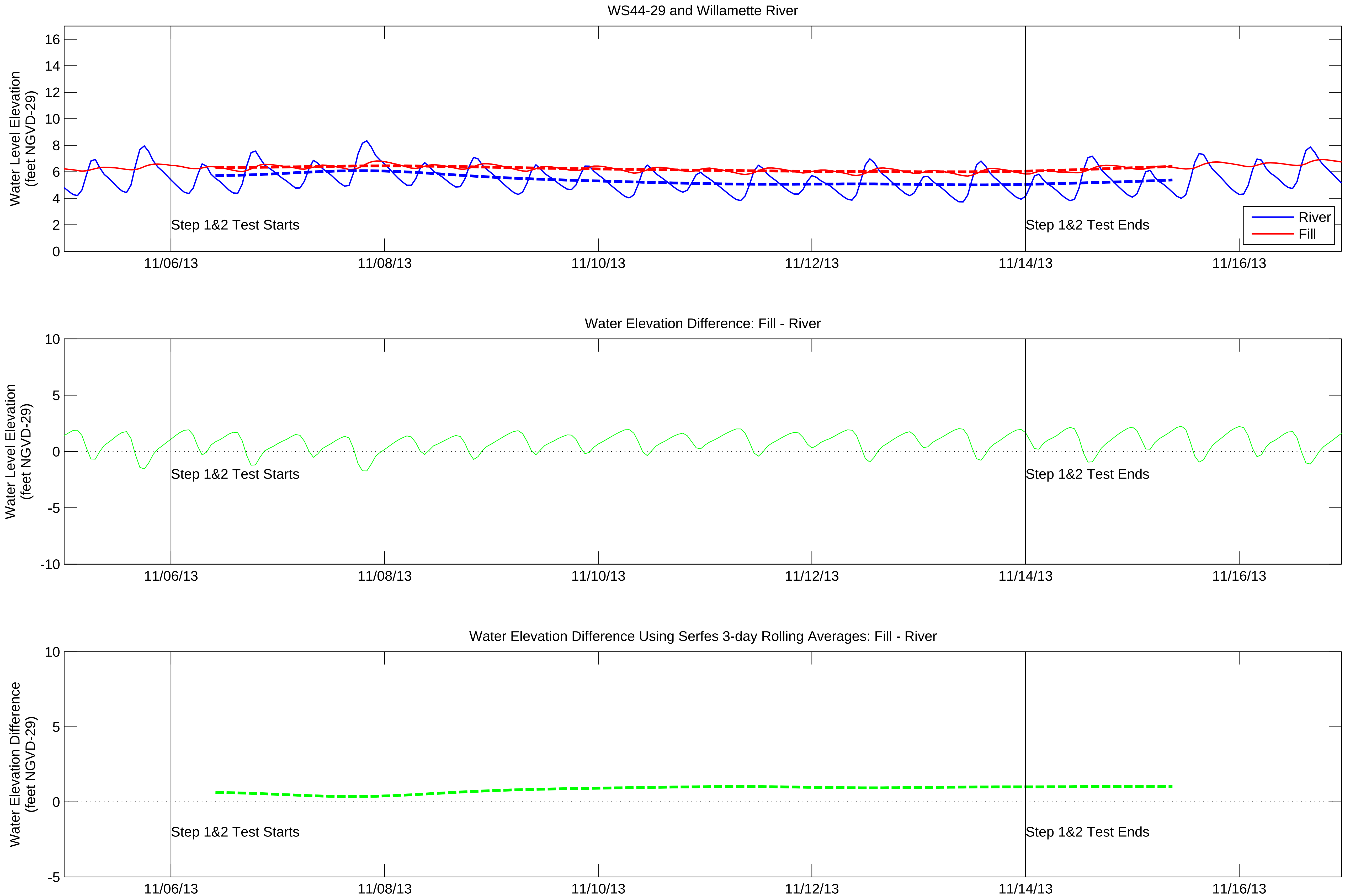

WS44-29 and Willamette River
Water Level Elevation
(feet NGVD-29)
16
14
12
10
8
6
4
2
0
Step 1&2 Test Starts
Step 1&2 Test Ends
River
Fill
11/06/13
11/08/13
11/10/13
11/12/13
11/14/13
11/16/13
Water Elevation Difference: Fill - River
Water Level Elevation
(feet NGVD-29)
10
5
0
-5
-10
Step 1&2 Test Starts
Step 1&2 Test Ends
11/06/13
11/08/13
11/10/13
11/12/13
11/14/13
11/16/13
Water Elevation Difference Using Serfes 3-day Rolling Averages: Fill - River
Water Elevation Difference
(feet NGVD-29)
10
5
0
-5
Step 1&2 Test Starts
Step 1&2 Test Ends
11/06/13
11/08/13
11/10/13
11/12/13
11/14/13
11/16/13

Figure 8

WS8-33 and Willamette River

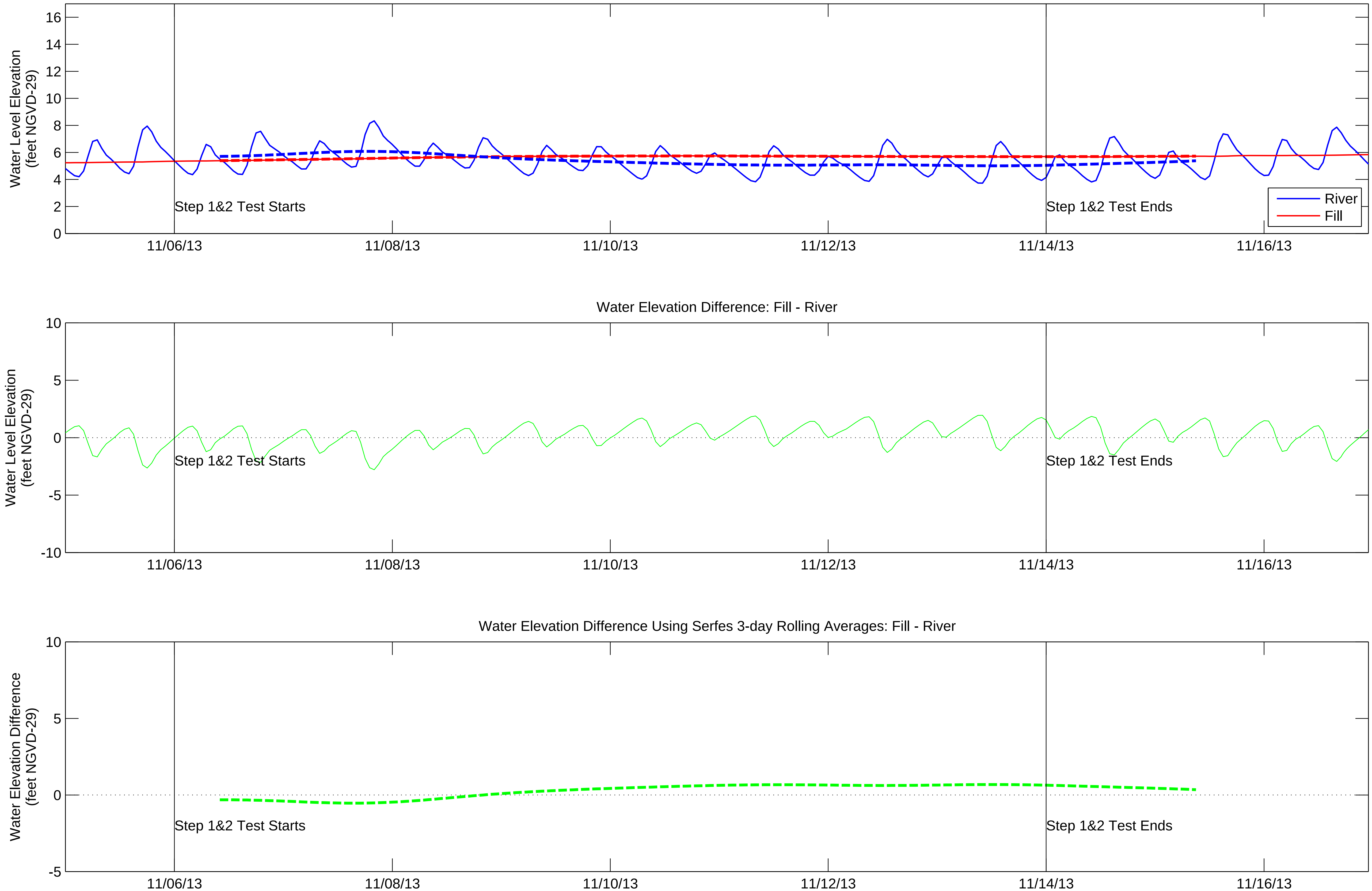


Figure 9

OW-2F and Willamette River

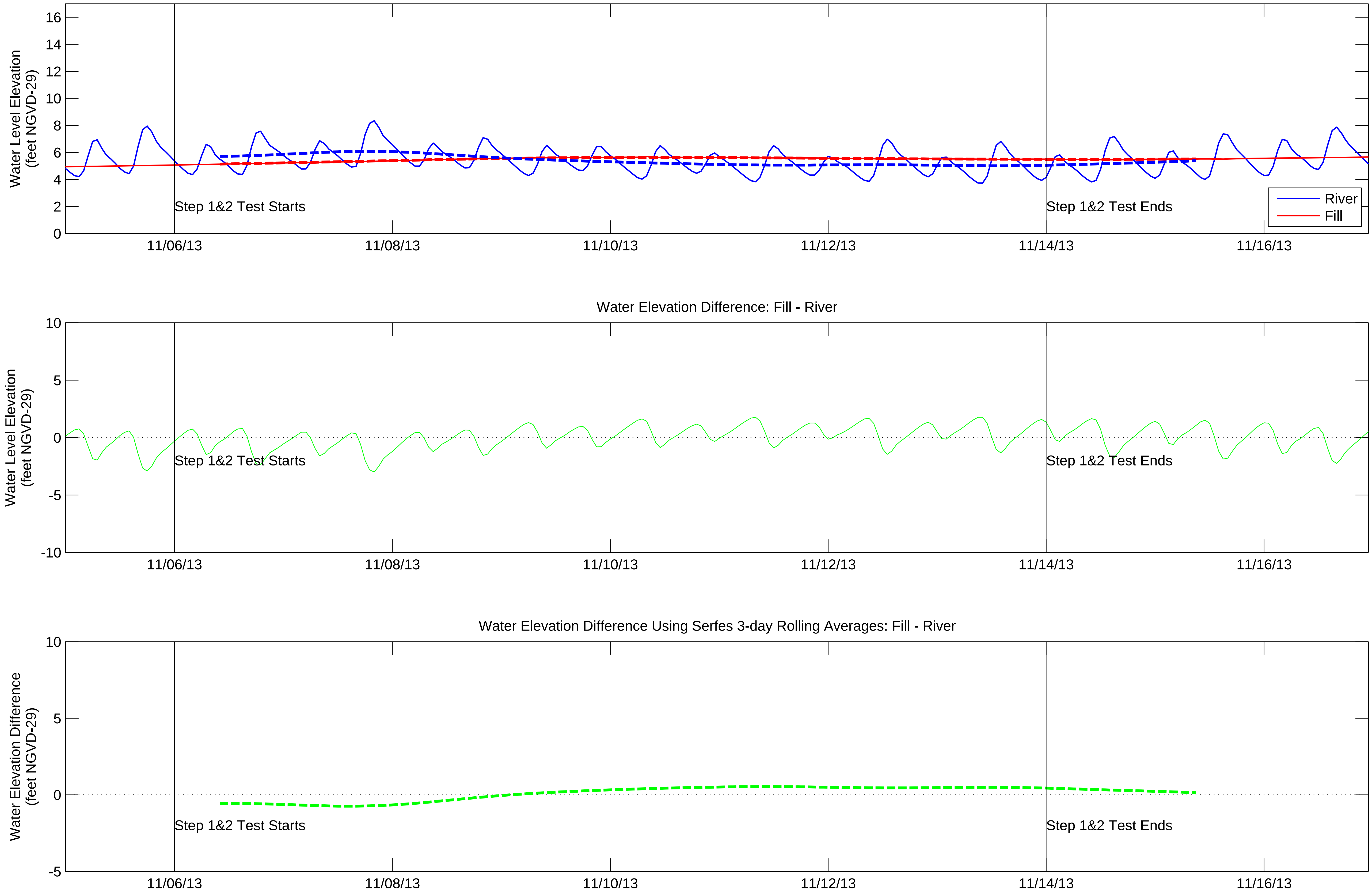


Figure 10

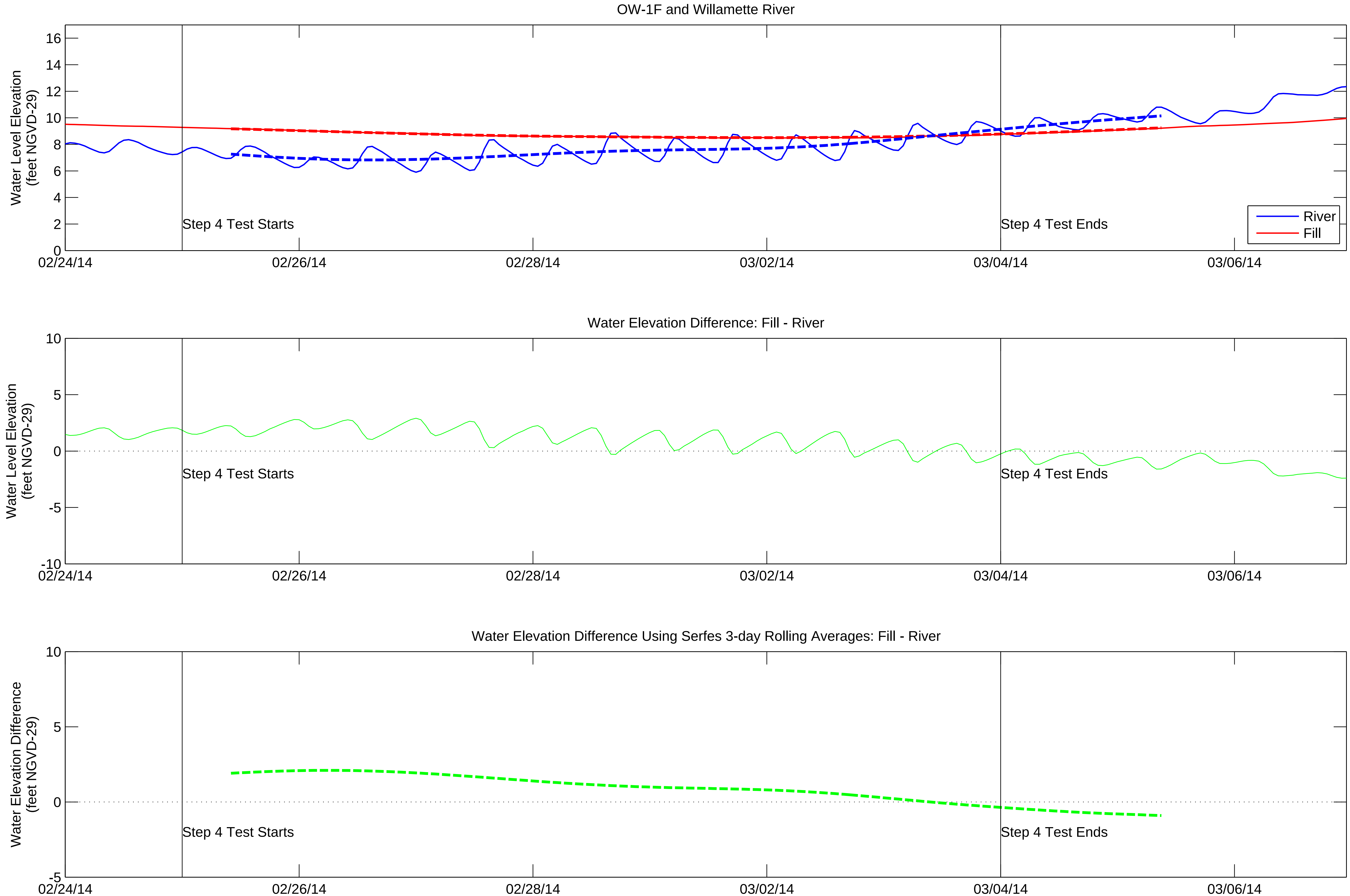
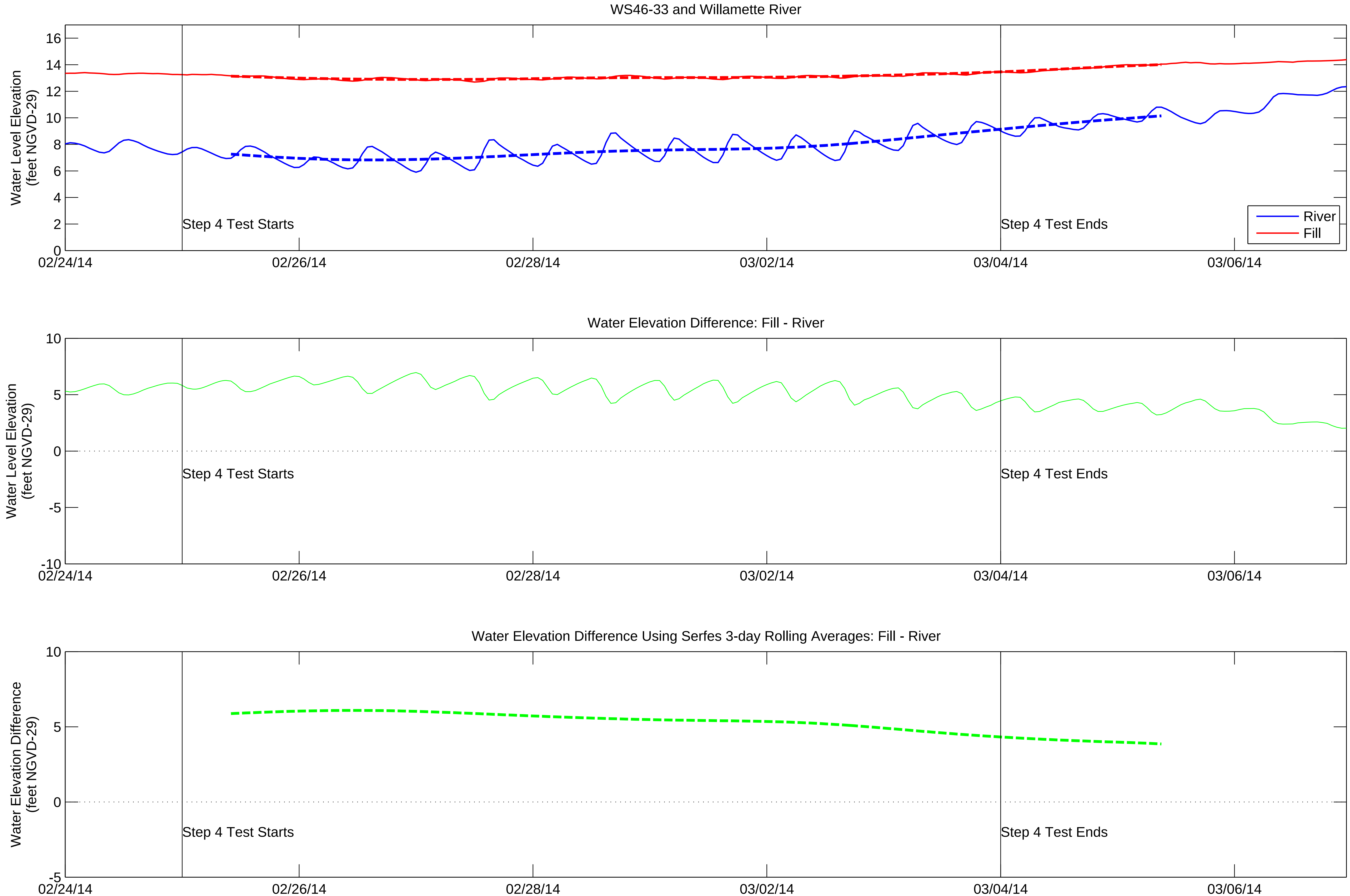

OW-1F and Willamette River
Water Level Elevation (feet NGVD-29)
Step 4 Test Starts
Step 4 Test Ends
River
Fill
Water Elevation Difference: Fill - River
Water Level Elevation (feet NGVD-29)
Water Elevation Difference Using Serfes 3-day Rolling Averages: Fill - River
Water Elevation Difference (feet NGVD-29)
02/24/14
02/26/14
02/28/14
03/02/14
03/04/14
03/06/14

Figure 11



WS46-33 and Willamette River
Water Level Elevation (feet NGVD-29)
Step 4 Test Starts
Step 4 Test Ends
River
Fill
02/24/14
02/26/14
02/28/14
03/02/14
03/04/14
03/06/14
Water Elevation Difference: Fill - River
Water Level Elevation (feet NGVD-29)
Step 4 Test Starts
Step 4 Test Ends
Water Elevation Difference Using Serfes 3-day Rolling Averages: Fill - River
Water Elevation Difference (feet NGVD-29)
Step 4 Test Starts
Step 4 Test Ends

Figure 12

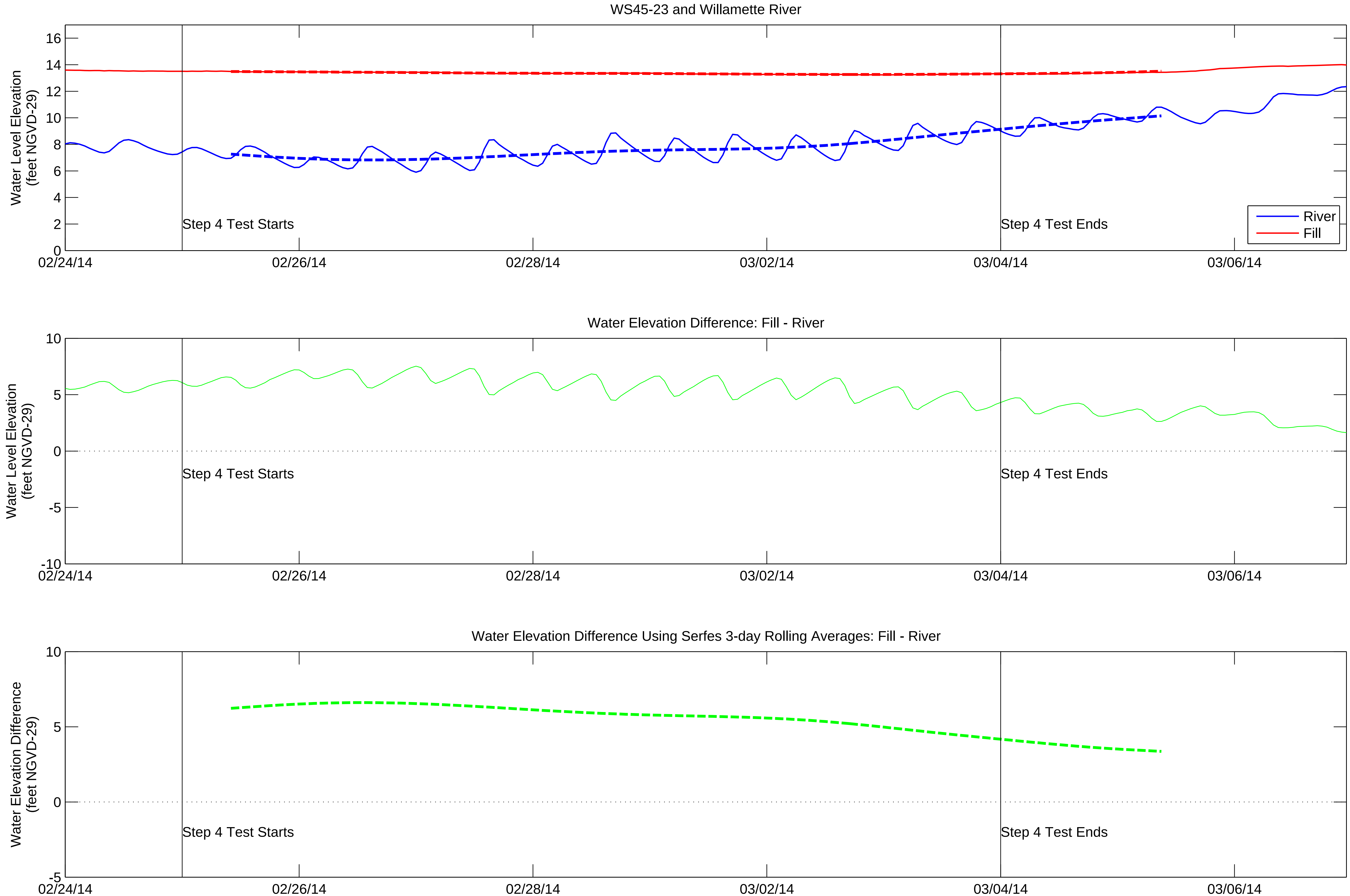

WS45-23 and Willamette River
Water Level Elevation (feet NGVD-29)
16
14
12
10
8
6
4
2
0
Step 4 Test Starts
Step 4 Test Ends
River
Fill
02/24/14
02/26/14
02/28/14
03/02/14
03/04/14
03/06/14
Water Elevation Difference: Fill - River
Water Level Elevation (feet NGVD-29)
10
5
0
-5
-10
Step 4 Test Starts
Step 4 Test Ends
02/24/14
02/26/14
02/28/14
03/02/14
03/04/14
03/06/14
Water Elevation Difference Using Serfes 3-day Rolling Averages: Fill - River
Water Elevation Difference (feet NGVD-29)
10
5
0
-5
Step 4 Test Starts
Step 4 Test Ends
02/24/14
02/26/14
02/28/14
03/02/14
03/04/14
03/06/14

Figure 13

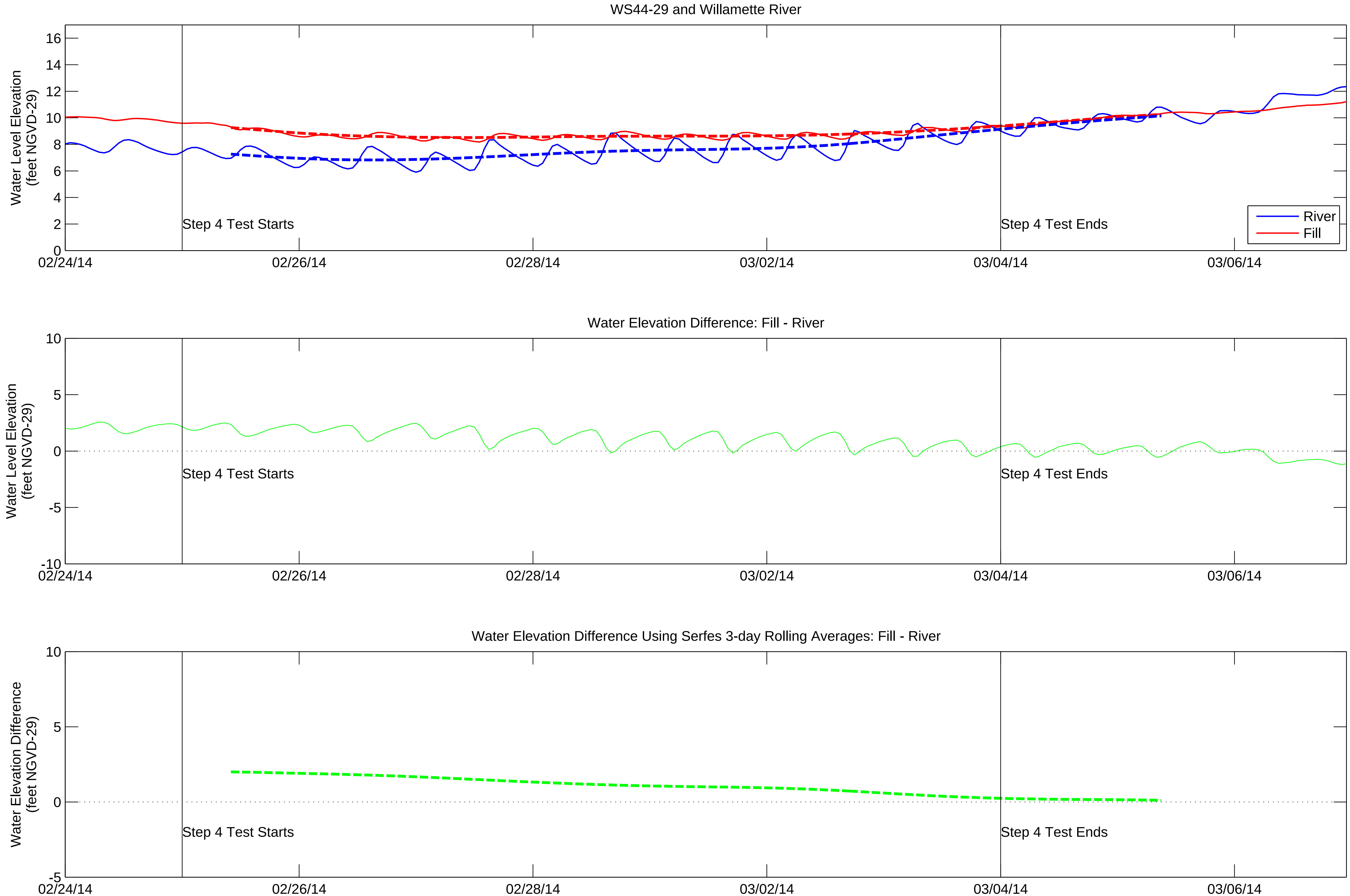
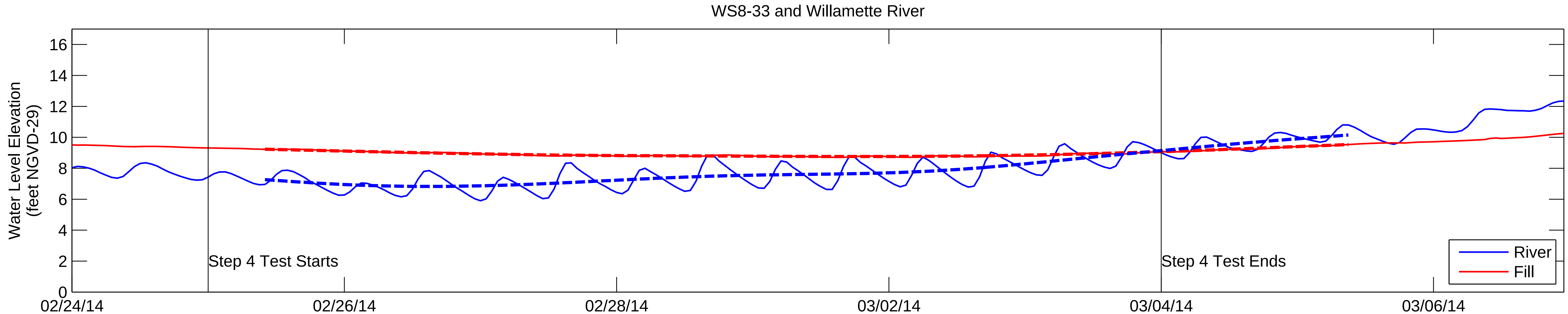
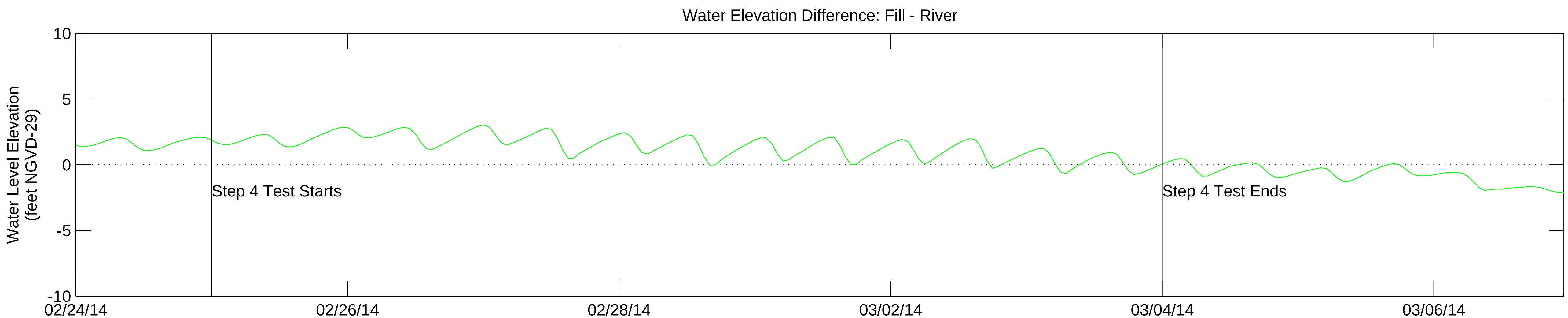

WS44-29 and Willamette River
Water Level Elevation
(feet NGVD-29)
Step 4 Test Starts
Step 4 Test Ends
River
Fill
02/24/14
02/26/14
02/28/14
03/02/14
03/04/14
03/06/14
Water Elevation Difference: Fill - River
Water Level Elevation
(feet NGVD-29)
Step 4 Test Starts
Step 4 Test Ends
Water Elevation Difference Using Serfes 3-day Rolling Averages: Fill - River
Water Elevation Difference
(feet NGVD-29)
Step 4 Test Starts
Step 4 Test Ends

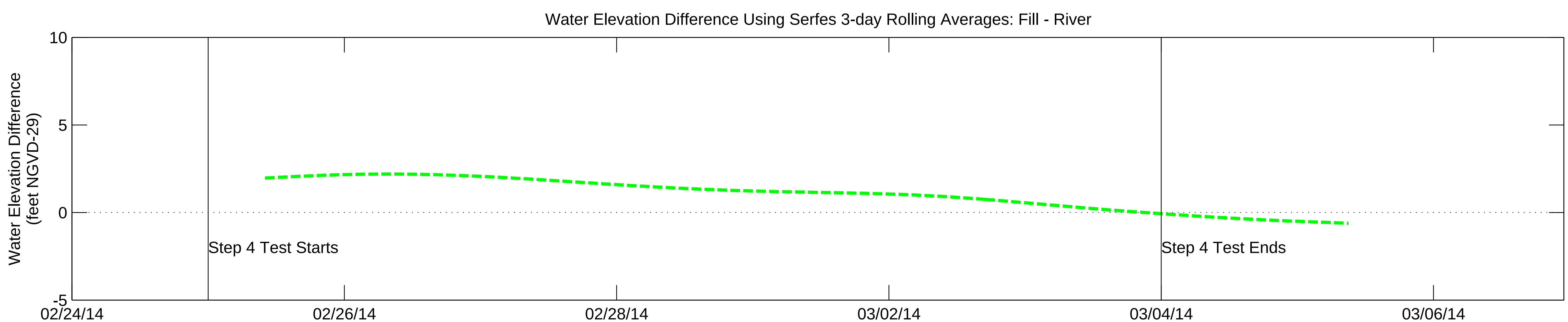
Figure 14



WS8-33 and Willamette River
Water Level Elevation
(feet NGVD-29)
16
14
12
10
8
6
4
2
0
Step 4 Test Starts
Step 4 Test Ends
River
Fill
02/24/14
02/26/14
02/28/14
03/02/14
03/04/14
03/06/14

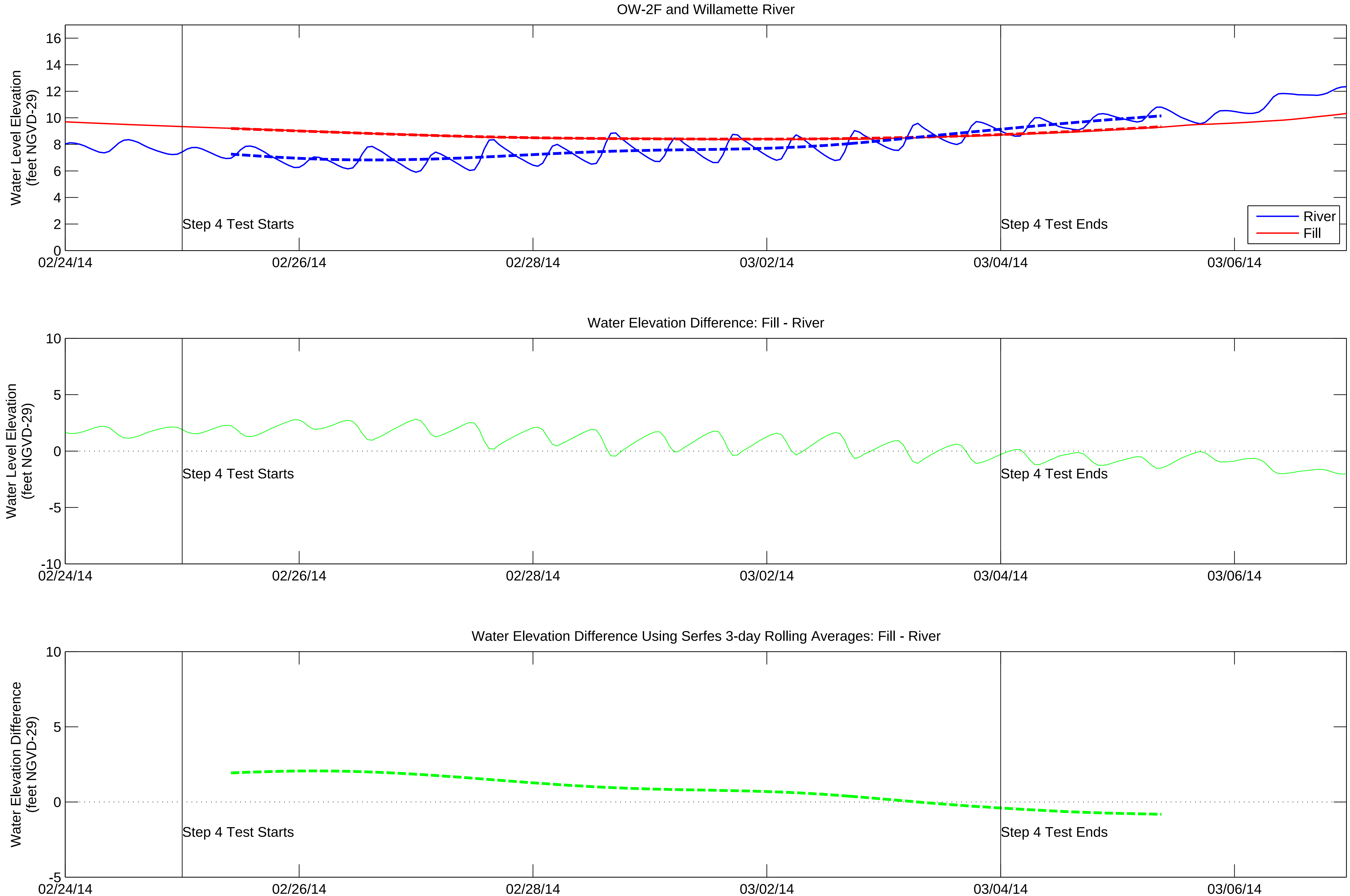


Water Elevation Difference: Fill - River
Water Level Elevation
(feet NGVD-29)
10
5
0
-5
-10
Step 4 Test Starts
Step 4 Test Ends
02/24/14
02/26/14
02/28/14
03/02/14
03/04/14
03/06/14



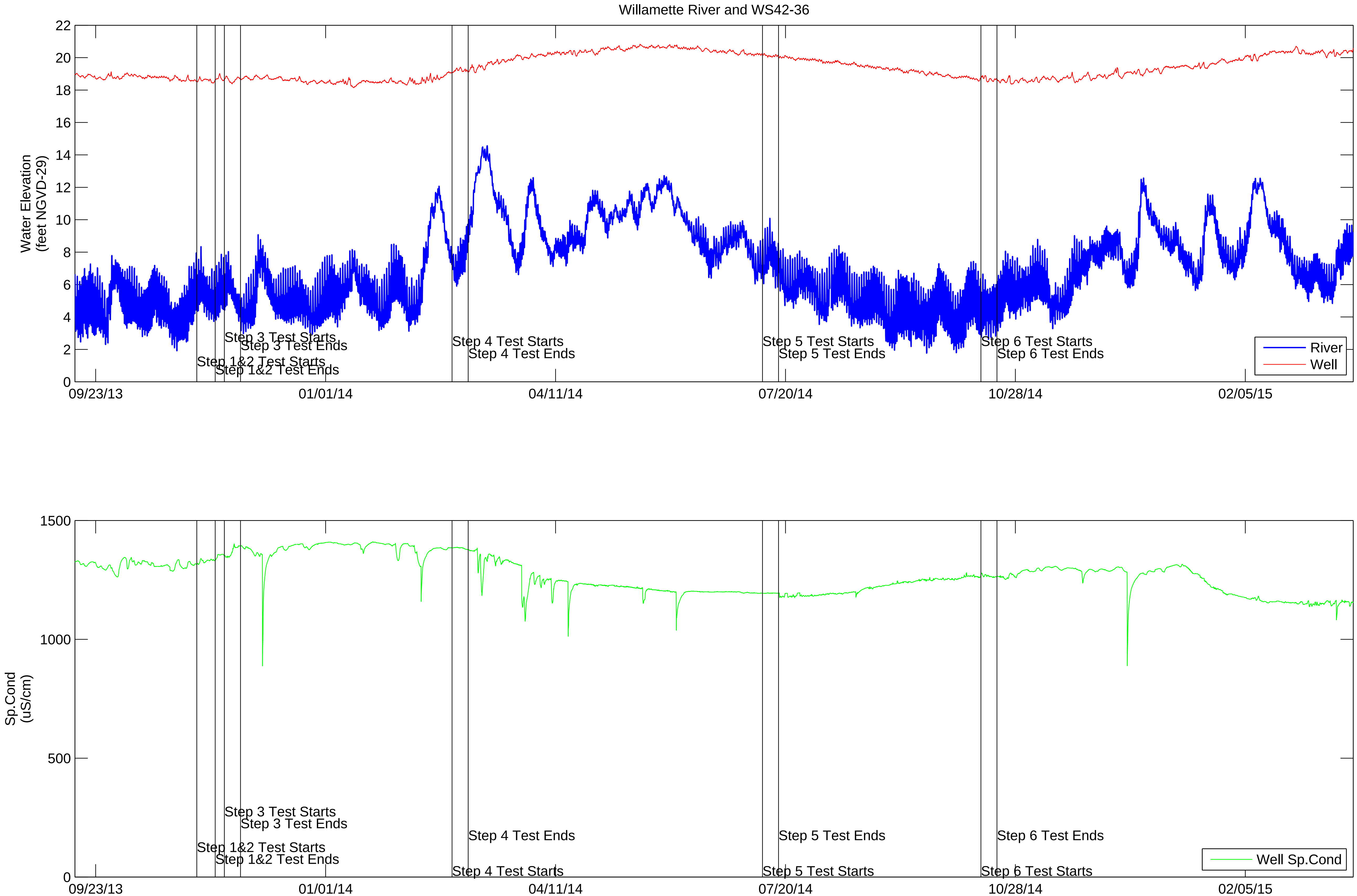
Water Elevation Difference Using Serfes 3-day Rolling Averages: Fill - River
Water Elevation Difference
(feet NGVD-29)
10
5
0
-5
Step 4 Test Starts
Step 4 Test Ends
02/24/14
02/26/14
02/28/14
03/02/14
03/04/14
03/06/14

Figure 15



OW-2F and Willamette River
Water Level Elevation (feet NGVD-29)
16
14
12
10
8
6
4
2
0
Step 4 Test Starts
Step 4 Test Ends
River
Fill
02/24/14
02/26/14
02/28/14
03/02/14
03/04/14
03/06/14
Water Elevation Difference: Fill - River
Water Level Elevation (feet NGVD-29)
10
5
0
-5
-10
Step 4 Test Starts
Step 4 Test Ends
02/24/14
02/26/14
02/28/14
03/02/14
03/04/14
03/06/14
Water Elevation Difference Using Serfes 3-day Rolling Averages: Fill - River
Water Elevation Difference (feet NGVD-29)
10
5
0
-5
Step 4 Test Starts
Step 4 Test Ends
02/24/14
02/26/14
02/28/14
03/02/14
03/04/14
03/06/14

Figure 16



Willamette River and WS42-36
Water Elevation
(feet NGVD-29)
22
20
18
16
14
12
10
8
6
4
2
0
09/23/13
01/01/14
04/11/14
07/20/14
10/28/14
02/05/15
Step 1&2 Test Starts
Step 1&2 Test Ends
Step 3 Test Starts
Step 3 Test Ends
Step 4 Test Starts
Step 4 Test Ends
Step 5 Test Starts
Step 5 Test Ends
Step 6 Test Starts
Step 6 Test Ends
River
Well
Sp.Cond
(uS/cm)
1500
1000
500
0
Well Sp.Cond

Figure 17

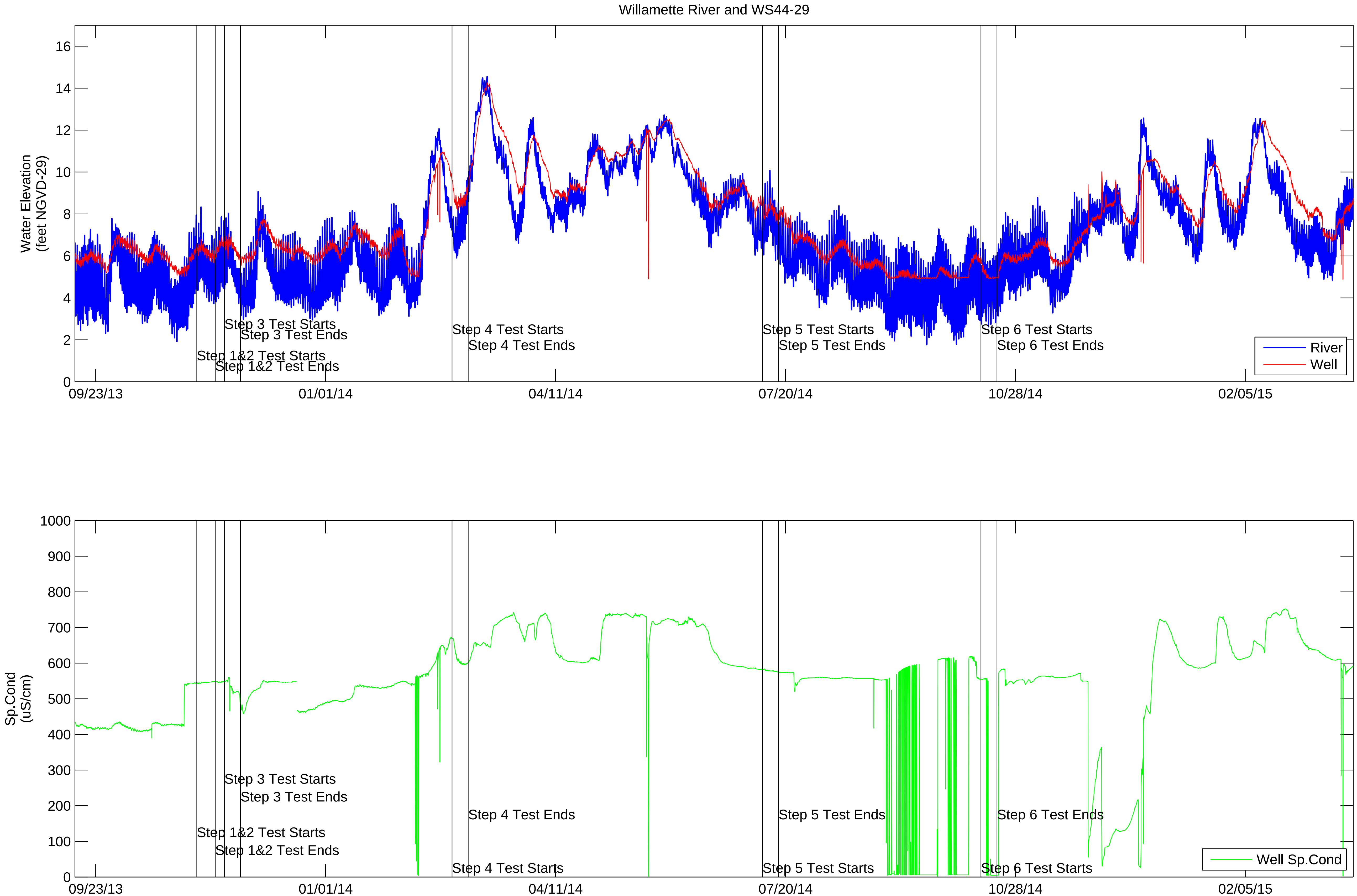
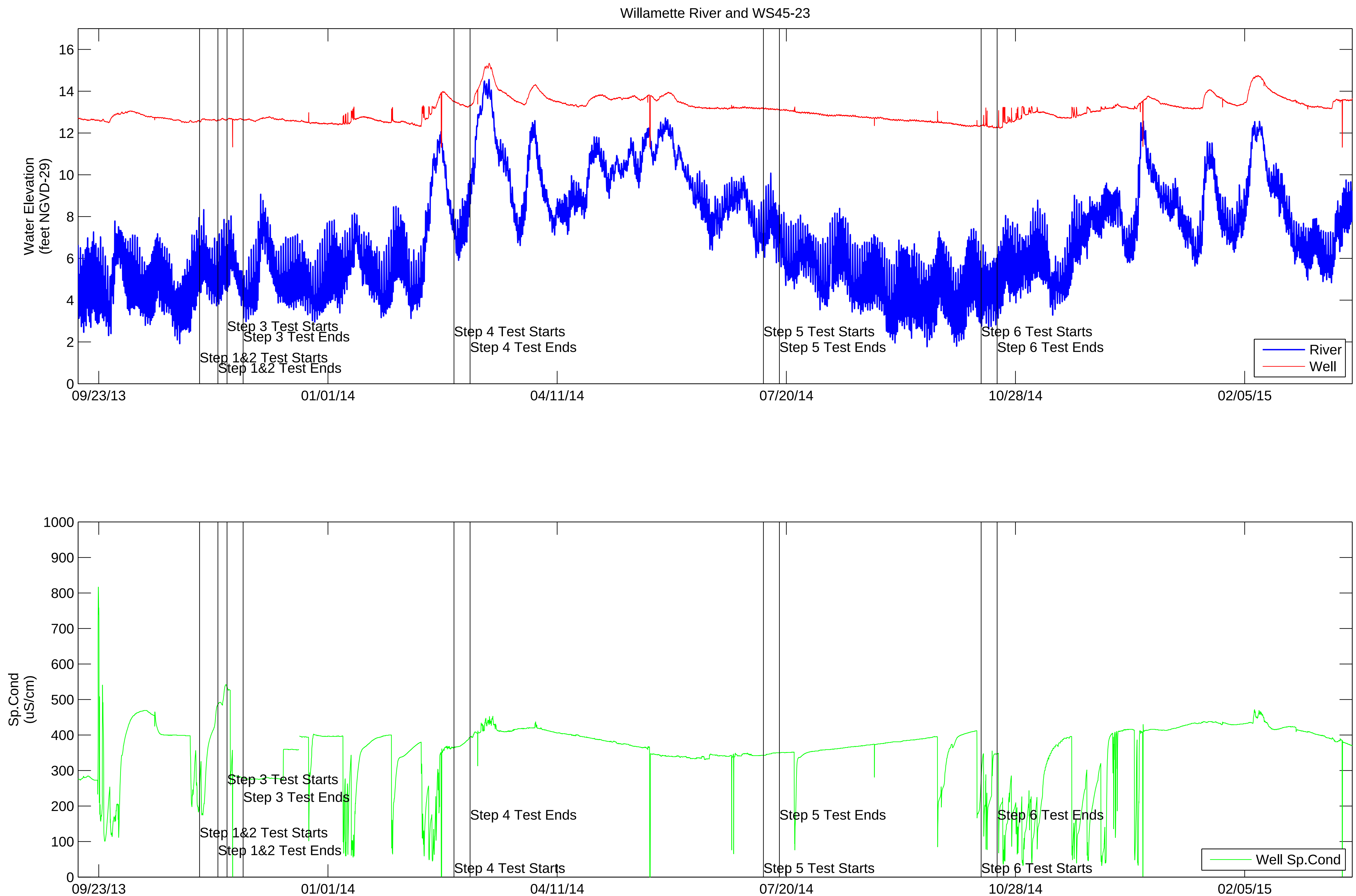
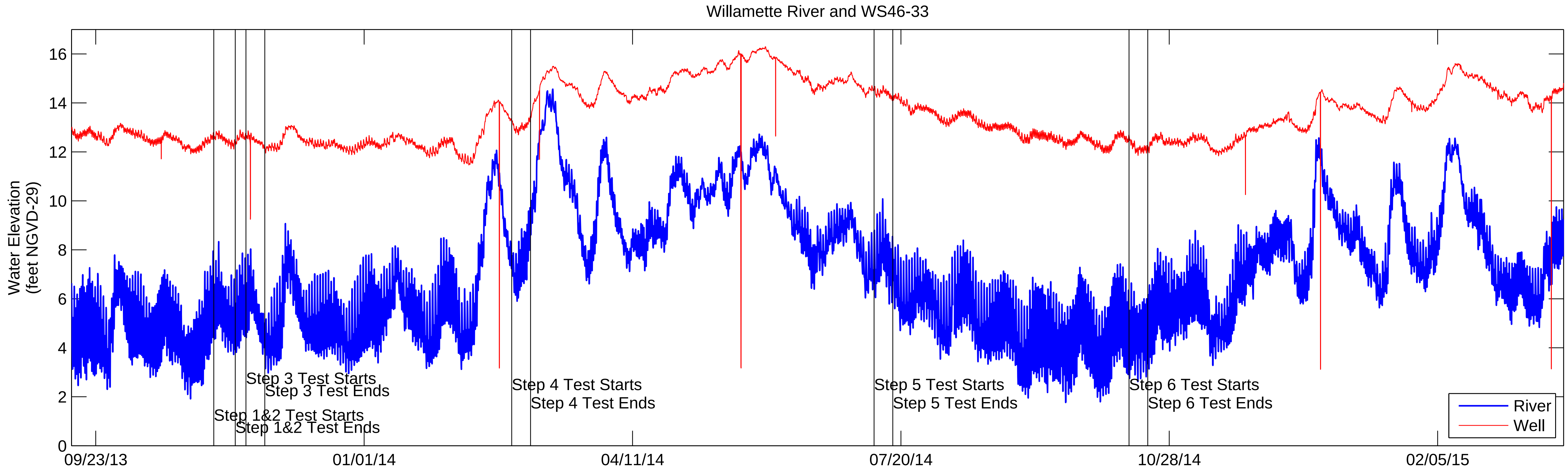

Willamette River and WS44-29
Water Elevation
(feet NGVD-29)
16
14
12
10
8
6
4
2
0
09/23/13
01/01/14
04/11/14
07/20/14
10/28/14
02/05/15
Step 1&2 Test Starts
Step 1&2 Test Ends
Step 3 Test Starts
Step 3 Test Ends
Step 4 Test Starts
Step 4 Test Ends
Step 5 Test Starts
Step 5 Test Ends
Step 6 Test Starts
Step 6 Test Ends
River
Well
Sp.Cond
(uS/cm)
1000
900
800
700
600
500
400
300
200
100
0
Well Sp.Cond

Figure 18



Willamette River and WS45-23
Water Elevation (feet NGVD-29)
16
14
12
10
8
6
4
2
0
09/23/13
01/01/14
04/11/14
07/20/14
10/28/14
02/05/15
Step 3 Test Starts
Step 3 Test Ends
Step 1&2 Test Starts
Step 1&2 Test Ends
Step 4 Test Starts
Step 4 Test Ends
Step 5 Test Starts
Step 5 Test Ends
Step 6 Test Starts
Step 6 Test Ends
River
Well
Sp.Cond (uS/cm)
1000
900
800
700
600
500
400
300
200
100
0
Well Sp.Cond

Figure 19


Willamette River and WS46-33
Water Elevation
(feet NGVD-29)
16
14
12
10
8
6
4
2
0
09/23/13
01/01/14
04/11/14
07/20/14
10/28/14
02/05/15
Step 3 Test Starts
Step 3 Test Ends
Step 1&2 Test Starts
Step 1&2 Test Ends
Step 4 Test Starts
Step 4 Test Ends
Step 5 Test Starts
Step 5 Test Ends
Step 6 Test Starts
Step 6 Test Ends
River
Well

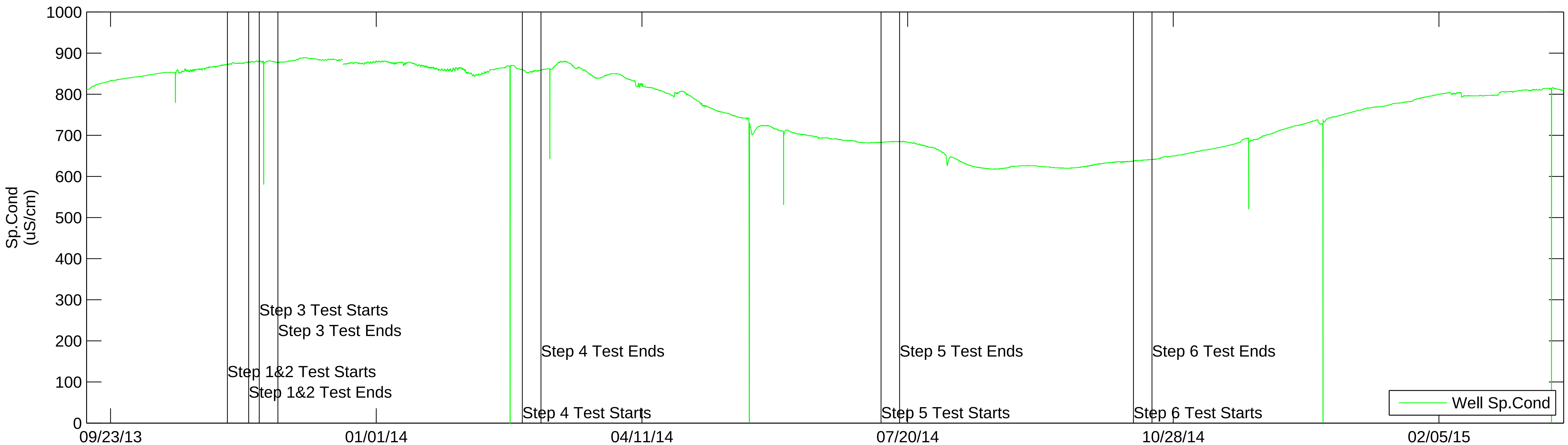
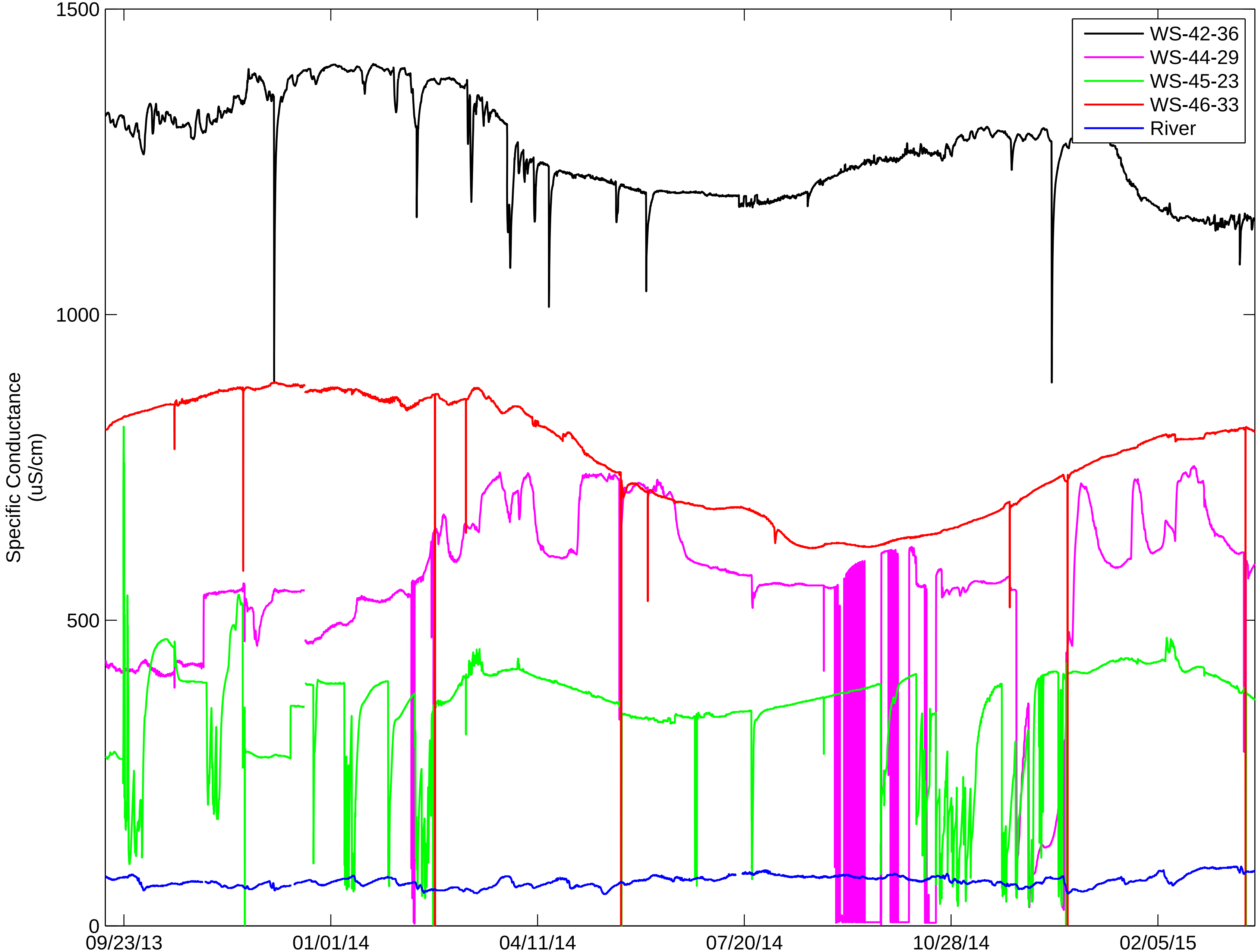

Sp.Cond
(uS/cm)
1000
900
800
700
600
500
400
300
200
100
0
09/23/13
01/01/14
04/11/14
07/20/14
10/28/14
02/05/15
Step 3 Test Starts
Step 3 Test Ends
Step 1&2 Test Starts
Step 1&2 Test Ends
Step 4 Test Ends
Step 4 Test Starts
Step 5 Test Ends
Step 5 Test Starts
Step 6 Test Ends
Step 6 Test Starts
Well Sp.Cond

Figure 20: Specific Conductance



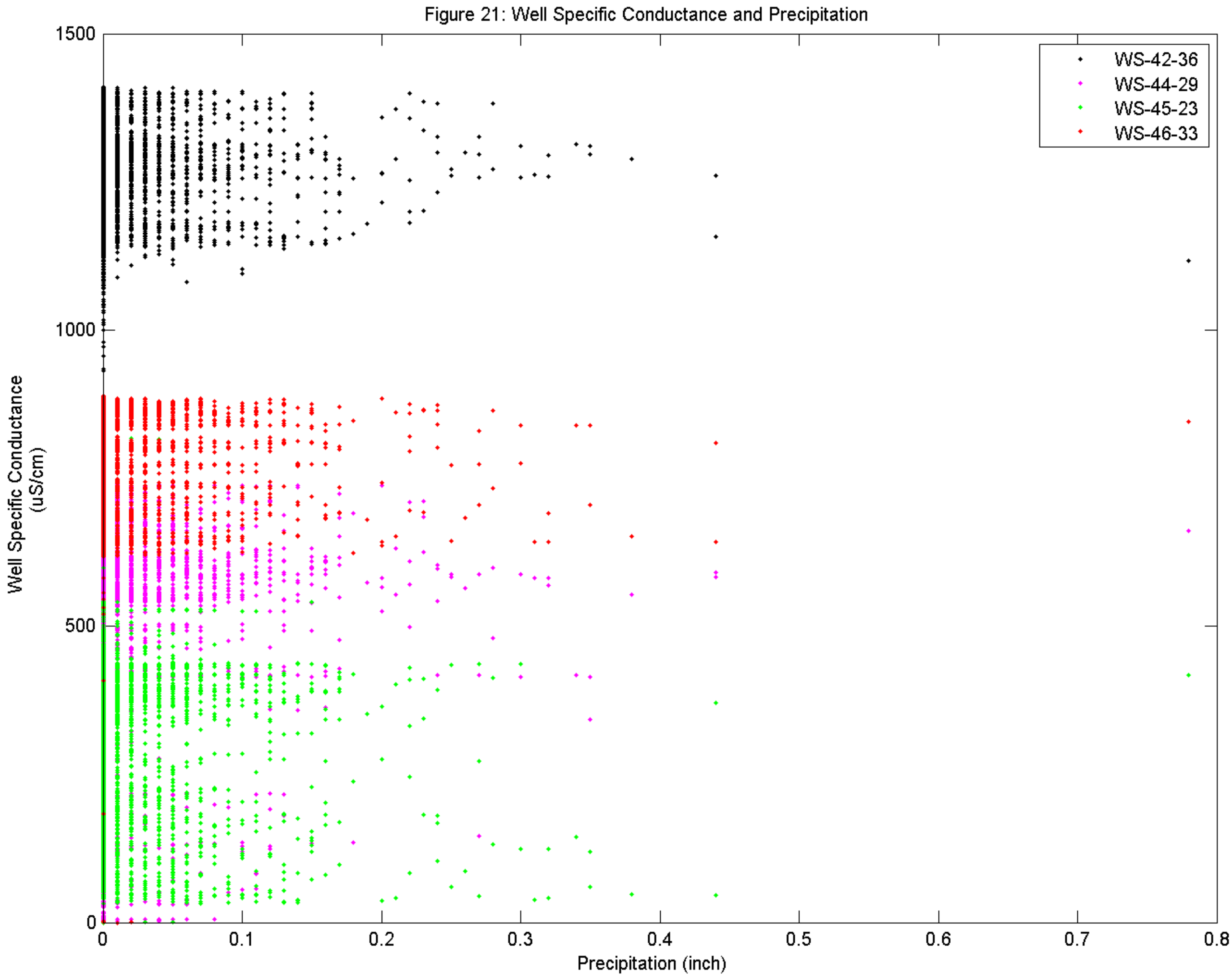


Figure 21: Well Specific Conductance and Precipitation
Well Specific Conductance
(uS/cm)
Precipitation (inch)
WS-42-36
WS-44-29
WS-45-23
WS-46-33
1500
1000
500
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8